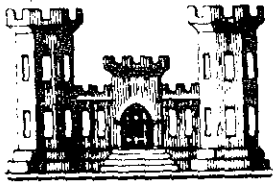
BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF

REVERE AND NANTASKET BEACHES

MASSACHUSETTS



DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS.

MARCH 1968

BEACH EROSION CONTROL REPORT

ON COOPERATIVE STUDY OF

REVERE AND NANTASKET BEACHES, MASSACHUSETTS

Table of Contents

(8) Character of Development: Amusement area on landward side of shore road.

(d) Between Eliot Circle and Northern Circle:

(1) Location: Pavilion at Bathhouse to Pavilion at Revere Street.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H. W.: No sand beach. Water line reaches concrete apron at high water.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Pavilion at Revere Street.

(6) Composition of Shore: Sand is fine below high water line.

(7) Protective Structures: Concrete parapet wall along sidewalk. Concrete apron fronting wall between pavilions. Pavilion fronted by concrete.

(8) Character of Development: Amusement area on landward side of shore road.

e. Between Eliot Circle and Northern Circle:

(1) Location: Pavilion at Revere Street to Pavilion at Oak Island Street.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H. W.: Beach widens from 0 feet at Revere Street Pavilion to about 160 feet at Oak Island Street Pavilion.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Pavilion at Oak Island Street.

(6) Composition of Shore: Shore is composed of fine sand which is being wind-blown and piled up against wall.

PLATES

PHOTOGRAPHS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO

NEDED-R

28 March 1968

SUBJECT: Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts

TO: Chief of Engineers
ATTN: ENGCW-PD

SYLLABUS

This beach erosion control study covers Revere and Nantasket Beaches which are owned by the Metropolitan District Commission, Commonwealth of Massachusetts.

The Division Engineer finds that erosion of these beaches during frequent high level storms has greatly reduced their protective effectiveness and recreational use capacity. Normal high tides approach or reach the seawalls which extend along the backshore at both beaches. Moderate damages to shorefront structures and some flooding of properties in back of the beaches have occurred during the more serious storms which have occurred on frequent occasions. The scarcity of natural beaches within convenient distance of the highly populated Metropolitan and suburban areas of Boston, coupled with the trend toward increasing recreational activities, including salt water bathing, makes development of recreational beaches extremely desirable. A network of modern highways also makes both of these areas easily accessible to residents of outlying areas and tourists who visit the Boston area.

The Division Engineer finds that, with the absence of a natural supply of sand that formerly replenished these beaches by natural processes, the most practical method of restoring the beaches is widening by direct placement of suitable sandfill.

The Division Engineer recommends that beach erosion control projects be adopted for Revere and Nantasket Beaches authorizing

Federal participation to the extent of one-half the cost of construction of the projects with the initial construction to be by the United States, described as follows:

Revere Beach. In lieu of the project authorized by the River and Harbor Act of 1954, provide beach widening by direct placement of suitable sandfill along 13,000 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a protective and recreational beach averaging 185 feet in width behind the mean high water line, a width commensurate with present and long-range comfortable recreational use requirements, and providing a more effective protective improvement fronting massive concrete stepped walls and structures.

Nantasket Beach. Provide beach widening by direct placement of suitable sandfill along about 6,800 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 17 feet above mean low water, thus furnishing a protective and recreational beach width averaging 190 feet behind the mean high water line.

The Division Engineer further recommends that Federal participation be authorized for both projects in the amount of one-half the cost of periodic nourishment which would involve deposition of suitable sand on the beaches at suitable intervals of time for the first 10 years of the project life. The periodic nourishment would be accomplished by the United States after receipt of the local share. After the first 10 years of project life, benefits and techniques would be reevaluated.

The presently estimated first cost of these projects is $2,400,000 for Revere Beach, and $2,000,000 for Nantasket Beach, to be borne jointly by the United States and the Commonwealth of Massachusetts. The Federal share of the first cost of the projects is established at fifty percent or $1,200,000 for Revere Beach and $1,000,000 for Nantasket Beach. The estimated annual amount of Federal participation for periodic nourishment at each beach is $25,000. The benefit-to-cost ratios, utilizing an interest rate of 3-1/4% and a project life of 50 years, are 4.2 for Revere Beach and 3.2 for Nantasket Beach.

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF REVERE AND NANTASKET BEACHES, MASSACHUSETTS

PART I - GENERAL

1. Authority. This study was made by the New England Division, Corps of Engineers, Department of the Army, in cooperation with the Commonwealth of Massachusetts (acting through the Metropolitan District Commission), under authority of Section 2 of the River and Harbor Act approved 3 July 1930, as amended and supplemented. Formal application for the cooperative study dated 22 August 1961 was approved by the Chief of Engineers on 19 September 1961.

2. Purpose. The purpose of the study, as stated in the application, is to review the problems at Revere and Nantasket Beaches, Massachusetts, for determining the best methods of restoring and stabilizing the beaches and protecting the beach developments.

3. Prior Reports. Cooperative beach erosion control studies of Revere and Nantasket Beaches have been made previously with the Metropolitan District Commission. The Division Engineer's report on Revere Beach was submitted to the Chief of Engineers on 1 June 1949. It was later printed in House Document No. 146, 82d Congress, 1st Session. The Chief of Engineers recommended that the United States adopt a project for the protection and improvement of the shore of Revere Beach Reservation between Northern Circle and a point near Shirley Avenue by authorizing participation through the contribution of Federal funds equal to one-third the first cost of construction.

4. The project consisted of beach widening by the placement of 522, 000 cubic yards of sandfill and was authorized by the River and Harbor Act of 1954. The cooperating agency constructed part of the project during 1954. The Metropolitan District Commission placed about 172, 000 cubic yards of sandfill dredged from an offshore borrow area which was pumped onto the beach between Revere Street

and Shirley Avenue. Loss and redistribution of the material occurred during the operation resulting in about 90,000 cubic yards of material remaining on the beach within the area of placement.

5. The Division Engineer's report on Nantasket Beach was submitted to the Chief of Engineers on 1 June 1949. It was not printed as a Congressional document. The report stated that Nantasket Beach was stable and recommended that the problem of maintenance of the beach for recreational use be accomplished by local interests entirely at their own expense by burying and covering stone deposits or by removal of stones and replacing them with equal volumes of sand.

6. Description. Revere Beach is located in the City of Revere, Suffolk County, Massachusetts, approximately 7 miles north of the main entrance channel to Boston Harbor and 6 miles northeast of the City of Boston. The location is included in United States Coast and Geodetic Survey Chart No. 1207, United States Geological Survey Boston Bay quadrangle and the drawings accompanying this report.

7. The beach extends a distance of approximately 3-1/2 miles northward from Roughan's Point to the mouth of the Saugus River. The southern half of the beach is developed as an extensive amusement area. The northern half of the beach is developed as a middle-class residential district, with the greatest population being concentrated in the Point of Pines area.

8. The Revere Beach Reservation comprises a wide boulevard, including sidewalks, a series of seawalls, pavilions, and retaining walls along the seaward edge of the boulevard, along the backshore of the beach. A large pleasure-park development, containing all types of rides, games, amusement devices, and refreshment stands, borders the southerly 6,000 feet of the Reservation. Bathhouse facilities are also conveniently located at the central portion of the beach. Private residences interspersed with refreshment stands and restaurants border the balance of the Reservation. The area north of the Reservation, designated as Point of Pines, is a densely populated, permanent residential area bounded by a paved town road paralleling a beach. The road is partially protected by miscellaneous walls, bulkheads, and riprap placements. The area south of the /

PHOTO 1. Revere Beach, 20 August 1966 - Looking south from Northern Circle during a normal high tide.

PHOTO 2. Revere Beach, 20 August 1966 - Looking north from Elliot Circle during a normal high tide.

Reservation designated as Roughan's Point is a summer and year-round residential area abutted by a seawall and riprap shore protection constructed by the Massachusetts Department of Public Works.

9. Revere Beach is exposed to direct action from the open ocean from the east and through the southeast quadrant. Some protection from storms from this quadrant is afforded by Cherry Island breakwater. The beach is afforded protection from direct attack from the northeast by Big and Little Nahant. Storms originating from the northeast quadrant attack the beach through the refraction and diffraction of the storm waves around Nahant.

10. Revere Beach is connected to other parts of the City of Revere and to all sections of Metropolitan Boston by trunk highways. A principal State highway route parallels the beach about 1,000 feet inland. The amusement area of the beach is served directly by the Massachusetts Bay Transportation Authority system. Free public parking areas are provided along most sections of the Metropolitan District Commission Reservation. The beach is open to full and free use by the public. The location and accessibility of the area, the original long, wide sandy beach, the development of the State-operated reservation, and the development of the amusement park have made Revere Beach the most popular and most widely used beach in Massachusetts.

11. Nantasket Beach is located in the Town of Hull, Plymouth County, Massachusetts, about 4 miles southeast of the main entrance to Boston Harbor and 12 miles southeast of the City of Boston. The study area comprises the southerly end of the beach. The location is included on United States Coast and Geodetic Survey Chart No. 246, United States Geological Survey, Nantasket quadrangle and the drawings accompanying this report.

12. The Metropolitan District Commission Reservation at Nantasket consists of the following: A beach, seawall, highway, and a public area extending along the backshore containing parking grounds, bathhouse, pavilion, concert hall and a sanitary facility. The beach is composed of hard-packed sand in foreshore and offshore areas and soft sand and stones in backshore areas. The shore is constantly exposed to surf action.

13. The peninsula is traversed its entire length by paved roads which constitute the southerly end of the State circumferential highway around Metropolitan Boston. The beach is also connected by an express highway to the main route to Boston. Public transportation is provided by a bus system from Quincy which connects with several transportation systems serving the Metropolitan area. During the summer, there is direct steamboat service between the beach and the center of Boston, the beach terminal being on the Weir River side of the tombolo in about the center of the study area. Free public parking is provided in two large areas located between the highway and beach adjacent to the bathhouse and pavilion area. Other limited parking facilities are provided along the highway. Public walks and promenades are provided in front of the parking areas, bathhouse and pavilion. The principal bathhouse in the area is operated by the Metropolitan District Commission and provides facilities for 5, 000 bathers. Private bathhouses provide facilities for 2, 000 to 3, 000 bathers. This beach and Paragon Park, a large amusement center located directly in back of the beach, combine as a major attraction for the area.

14. Statement of the Problem and Improvement Desired. The problem at both beaches is general erosion due, principally, as in most areas, to the advanced development of the shore and the erection of protective structures which have eliminated the sources for the supply of littoral material to the shore which formerly provided some equilibrium under natural shore processes.

15. The specific problem at Revere Beach appears to be caused by the littoral drift, combined with offshore losses, of the existing material and the insufficient supply of replenishment material. During frequent serious storms, waves breaking on the massive concrete walls are observed to increase losses from the backshore by scouring at and some distance seaward of the toe of the wall. The construction of the authorized project was discontinued in 1954 due to the inability to hold the sand at the desired location. The fineness of the borrow material contributed substantially to the loss of beach fill. Local interests desire consideration of groins as a means of reducing loss of beach fill.

16. Nantasket Beach is also faced with a deficiency of replenishment material. Local interests state that there is little or no dry beach for recreational use above high water. They desire restoration and protection of the beach and beach developments.

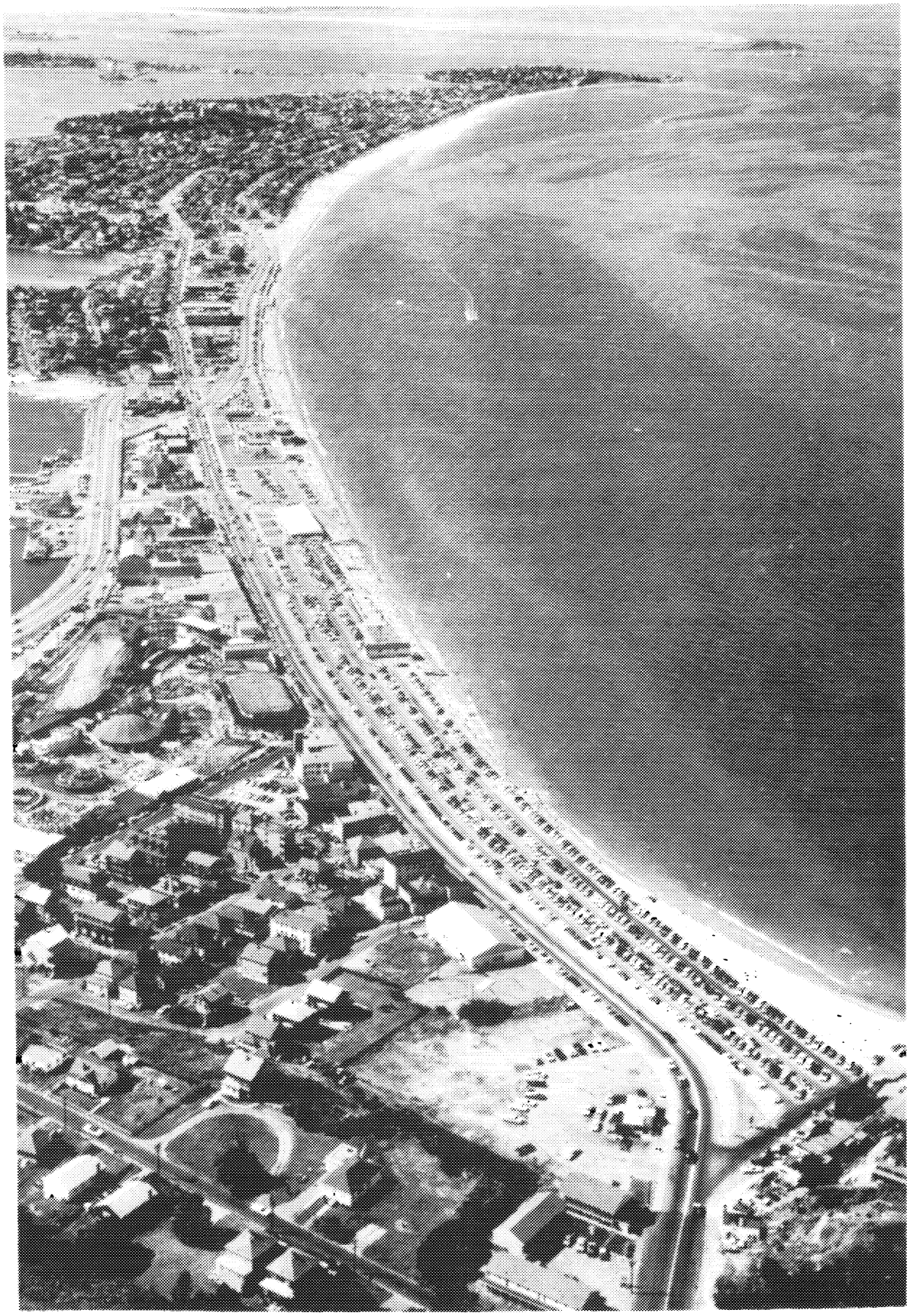


PHOTO 3. Nantasket Beach, 20 August 1966 - Shorefront at about a normal high tide - looking north.

PHOTO 4. Nantasket Beach, 20 August 1966 - Bathers utilize limited dry beach here during high tides.

PART II - FACTORS PERTINENT TO THE PROBLEM

17. Geomorphology. In general, the shoreline of New England is one of submergence of the land with respect to the level of the sea.

18. Revere Beach was constructed by the distribution of glacial till from Young's Hill, Beachmont and Cherry Island and of outwash sands and gravels from the areas of Oak Island and Revere Street. Cherry Island was tied to the mainland by a cuspate tombolo to form Roughan's Point with the island later eroding to form Cherry Island bar.

19. The modern Nantasket Beach assumed its present configuration only after a long series of shoreline processes. Originally, there were a number of drumlin islands in the area north of Atlantic Hill. The forces of erosion and accretion attacked these islands, wearing them away, and used the materials to build spits to tie the islands together. In the development of Nantasket Beach, there were a number of different combinations of islands and connecting tombolos. The final development of the beach resulted in the loss of five of the drumlin islands and the partial erosion of others.

20. Littoral Materials.

a. Characteristics. The character of littoral material was determined from surface samples of beach and nearshore materials taken along 7 profiles at Revere Beach and 3 profiles at Nantasket Beach. The results of sample analyses are contained in Appendix C. General descriptive information concerning composition of beaches, obtained by visual inspection, is contained in Appendix A. The samples at Revere Beach indicate that littoral materials consist largely of fine sands. There is some medium to coarse sand at the mean tide line with the offshore material becoming fine sand to silt. The samples at Nantasket Beach indicate that littoral materials range from silt all the way to gravel with the material at the seawall and at 30 feet below mean low water predominantly gravel. Most of the remaining material is fine sand.

b. Sources. Glacial deposits have constituted the principle source of beach materials around Revere. Some of the beach material in the area immediately west and north of Roughan's Point was derived

from the erosion of till found at Young's Hill, west of Crescent Beach, at Beachmont south of Roughan's Point and at Cherry Island bar. Outwash sands and gravels are present in the area between Young's Hill and Crescent Beach and along Revere Street. They may also be present offshore from these areas and the tops of these deposits may not be far from mean low water. The outwash sands and gravels rest on till and are an excellent source of beach material. Erosion of these and other similar deposits may have furnished and may still be furnishing small amounts of material for Revere Beach. In the growth of Nantasket Beach, several glacial hills or drumlins, such as Point Allerton, Allerton Hill, Strawberry Hill, Whitehead, and Sagamore Head figured predominantly. They are composed of till (boulder clay, "hard pan"), a compact unstratified, unsorted, surficial deposit containing angular and subangular fragments varying in size from clay to boulders, and all of them have been eroded considerably by waves and currents. Five drumlins were once located east of Nantasket Beach, but have been completely destroyed. All of these drumlins had been deposited by the continental glacier which disappeared from the Boston area approximately 30, 000 years ago. Waves and currents have deposited the clay and silt sizes of the eroded and destroyed drumlins in Boston Harbor and Massachusetts Bay and have used the larger sizes in the construction of Nantasket Beach. Probably more than 90% of the material in Nantasket Beach was drived from these drumlins. Strawberry Hill, Sagamore Head and Whitehead are now protected from marine erosion by the beaches which have prograded in front of them; Point Allerton and Allerton Hill are protected in most places by seawalls. No material, therefore, is now being added to Nantasket Beach from these drumlins, nor does it seem likely that any material is being added from the sites of the destroyed drumlins.

21. Littoral Forces.

a. Tides. Tides are semidiurnal. The mean range of tide at Revere Beach is 9. 0 feet and at Nantasket Beach is 9. 4 feet. The heights of extreme tides have not been recorded at Revere or Nantasket Beaches, but those observed over a long period of record at Boston Harbor provide an excellent indication of the magnitude of fluctuations from the mean. At Boston Harbor the predicted spring tides range up to 12. 0 feet; actual heights of extreme tides have been recorded up to 15. 0 feet above mean low water. Additional information on tides is given in Appendix E.

PHOTO 5. Nantasket Beach, 30 December 1959 - Waves pound shorefront as storm of 29 December 1959 moves offshore.

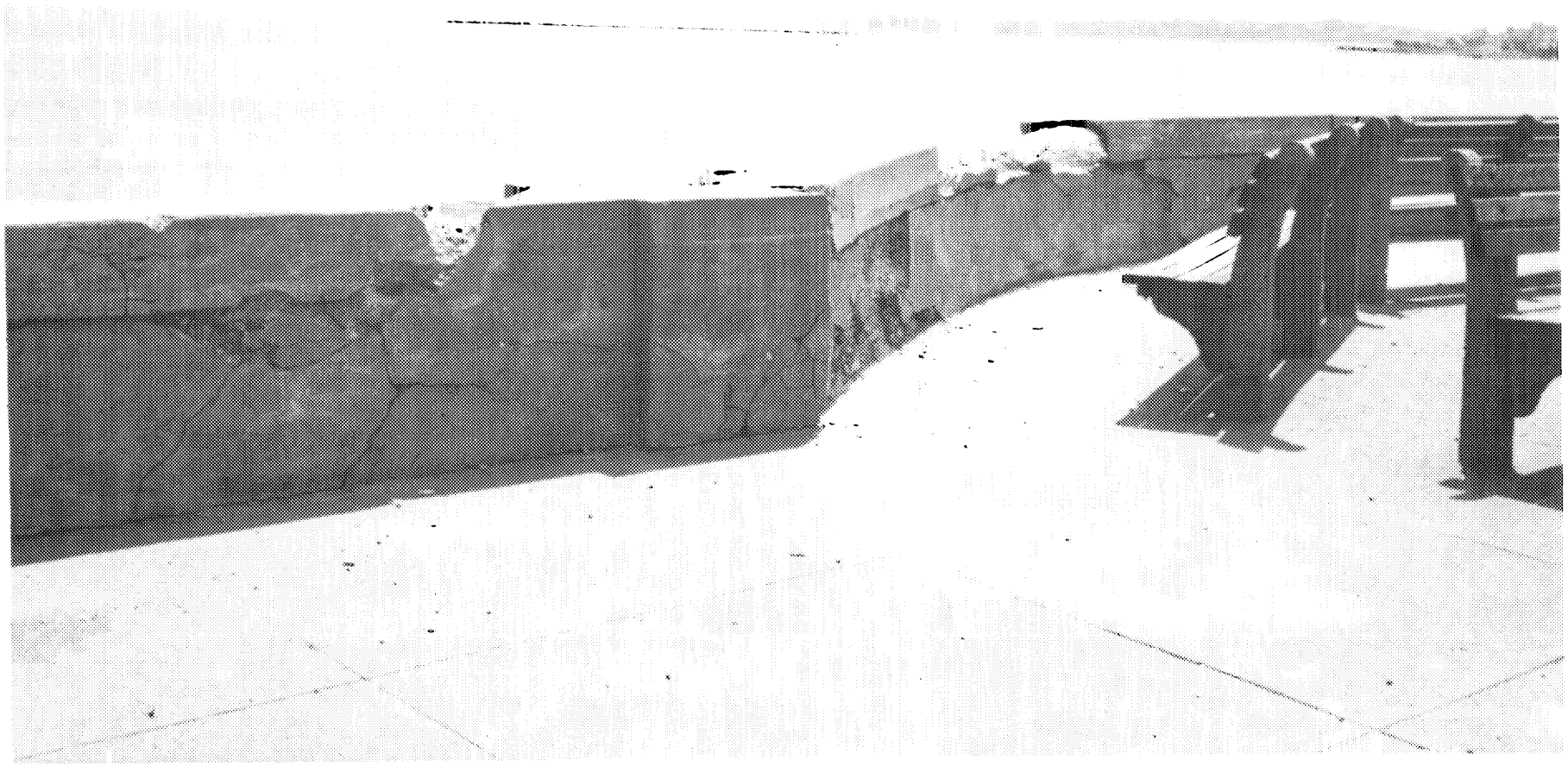


PHOTO 6. Revere Beach, 25 May 1965 - Looking southeast toward Cherry Island breakwater, note damage to walls caused by wave action occurring during serious storms.

PHOTO 7. Revere Beach, 30 December 1959 - The serious storm of December 1959 eroded sand from beach, exposing foundations of 15 beach shelters.

b. Winds. Records of winds observed by the United States Weather Bureau at Boston, Massachusetts, for the ten-year period, October 1949 to September 1959, show that prevailing winds blow offshore from westerly directions. Winds which blow onshore prevail from the east-southeast but winds from the east to northeast which occur for a shorter duration have a higher average velocity. A wind diagram based on data from the Boston Weather Bureau is shown on Plate 1. A summary of the data and more detailed descriptions are included in Appendix D, "Prevailing Winds and Storms."

c. Waves. No wave measurements are available for the immediate area. Hindcast wave data based on synoptic weather charts for locations along the North Atlantic coast have been prepared and published by the Coastal Engineering Research Center (formerly the Beach Erosion Board). A wave rose from this data for a location off Nauset Beach, Cape Cod, Massachusetts, is shown on Plate No. 1. It indicates that waves occur with greatest frequency from the northeast and east directions. Waves from the southeast quadrant occur with considerably less frequency. The waves having the greatest effect upon Revere Beach are those with a southeasterly component, approaching over unrestricted ocean areas. Waves from northeast and east directions refract and diffract around Nahant before approaching Revere Beach, but tend to concentrate in two areas, one just south of Northern Circle and one in the vicinity of Chester Avenue, which is best demonstrated by the massive concrete walls which have been constructed as a protective salt water flood control improvement. Nantasket Beach, however, is directly exposed to waves approaching from the northeast through the southeast.

d. Currents. Tidal currents along the coast flood to the north and ebb to the south. Maximum average velocities of ocean currents north and south of the study area vary from 0.3 to 0.8 knots.

e. Storms. Records from the United States Weather Bureau at Boston, Massachusetts, for the 75-year period 1870-1945, inclusive, show a high preponderance of northeast storms. These storms represent major disturbances of considerable duration, often accompanied by rain or snow, and high tides causing damage to low-lying shore developments. The wind rose on Plate No. 1 shows storm winds from the northeast occur most frequently. Revere Beach is sheltered from this direction but Nantasket Beach is exposed. Both study areas are directly exposed to storms from the southeast from which direction storm winds are least frequent and of short duration. More detailed storm data are included in Appendix D.

TABLE I - SHOREFRONT PROCESSES
REVERE BEACH, MASSACHUSETTS

Location Profile No.	PERIOD OF RECORD 1900-1904	1904-1910	1910-1946	1946-1962 (1)	1900-1946	1900-1962
1-2	Unknown	Unknown	Unknown	Large Accretion	Unknown	Unknown
2-3	Large Erosion	Large Erosion	Large Accretion	Large Accretion	Large Erosion	Minor Erosion
3-4	Minor Erosion	Moderate Erosion	Moderate Accretion	Moderate Accretion	Moderate Erosion	Moderate Erosion
4-6	Minor Accretion	Moderate Erosion	Moderate Erosion	Moderate Erosion	Moderate Erosion	Moderate Erosion
6-8	Minor Accretion	Moderate Erosion	Moderate Erosion	Minor Accretion	Moderate Erosion	Moderate Erosion
8-10	Minor Accretion	Moderate Erosion	Minor Accretion	Minor Accretion	Moderate Erosion	Moderate Erosion
10-12	Minor Accretion	Moderate Erosion	Minor Erosion	Minor Accretion	Moderate Erosion	Minor Erosion
12-14	Minor Accretion	Moderate Accretion	Moderate Accretion	Moderate Accretion	Moderate Accretion	Large Accretion
14-15	Minor Accretion	Moderate Accretion	Moderate Accretion	Moderate Accretion	Moderate Accretion	Large Accretion

(1) Reflects sandfill placed by MDC 1954.

22. Shore History.

a. Shoreline and Offshore Changes. The changes are best described by correlating and comparing all available information relating to the history of the shoreline. This includes a history of volumetric changes, profiles, and shoreline and offshore changes.

(1) Table I descriptively defines the history of erosion and accretion for Revere Beach. The shoreline change maps show the pattern of onshore and offshore erosion processes. At Revere Beach there has been periodic erosion and accretion throughout the years of record, with erosion predominating. An inspection of Table I illustrates the physical aspects of sand movement throughout about a half-century of record. The profiles numbered from the north to the south as shown on Plates 2 and 3 conveniently locate segments of the shoreline. Erosion and accretion have occurred at various times along the entire shorefront and the net result has been erosion for all but the southerly 1500 feet of the beach. This area has constantly enjoyed accretion. The area between Profiles 4 and 12 has a history of very nearly continuous erosion along this sector. Accretion when it has occurred has been of rather small quantities. Probably the most representative period of record, best portraying shorefront processes is 1910 through 1946. This, in general, indicates erosion from Profile 4 through Profile 12. In the period 1904 through 1910, it is reported that construction of the boulevard raised the highway 3 to 5 feet and resulted in fill placed on a 1 on 10 slope along the beach between Profiles 2 and 4. Large scale erosion occurred between Profiles 2 and 12 during this period. Possibly these changes reflect large scale erosion of this fill material. This would, logically, be expected for this type of construction with loose fill placed on steep slopes and directly exposed to wave action. However, during this period there could have been serious storms with flood levels and wave action of the magnitude necessary to cause the losses. The period of 1946 through 1962 reflects the sandfill composed of fine-grain sizes which was placed in 1954 along the beach between Profiles 4 and 12 in partial compliance with the authorized beach erosion project. The general accretion occurring along the reservation apparently demonstrates some littoral movement of this fine material with general accretion along the beach to the north and south. Inspection of the Shoreline Change Map, Plate 12, is quite indicative of the pattern of erosion processes occurring along the shorefront. The shape of the mean low water lines in general would seem to indicate some littoral movement of beach fill to the north and south from two particular areas; namely, from between Profiles 4 and

12 and Profiles 2 and 3, resulting in reshaping and building out of beach areas as much as 600 feet within the interior to over 1, 000 feet at the northern end. The fine nature of the beach fill, however, makes it easily susceptible to movement by wave action, and deposition on very flat seaward slopes, thus small vertical changes result in large horizontal changes.

(2) For Nantasket Beach, changes which have occurred along the shorefront since 1893 are shown on the Shoreline and Offshore Change Map, Plate 16. Details pertaining to shoreline changes are discussed in Appendix F entitled "Shoreline and Offshore Depth Changes." The movement of the shoreline and depth lines as shown on the map indicates a relatively stable beach has existed since 1847. However, the general lowering of the beach which has occurred rather uniformly over the study area cannot be reflected in the changes. It rather indicates no general accretion or concentration of erosion within the study area.

b. Prior Corrective Action and Existing Structures.

(1) The problem of overtopping of Revere Beach during serious high level storms has been a recurring one over the years. This has caused some erosion of beach fill and deposited some shingle on portions of the beach. Minor flooding of the developed area has been attributed to tidal waters which overtop the highway when waves break on the seawalls. When this occurs, sand is deposited on the highway. To reduce tidal flooding of the commercial and residential area and protect the ocean highway from erosive forces, a variety of structures have been constructed along the backshore. These structures range from massive concrete walls in areas subjected to concentrated wave forces to concrete capped steel sheet pile bulkheads in areas fronted by a wider beach. The top elevation of these structures ranges between 18. 0 feet above mean low water and 21. 5 feet above mean low water. As recently as 1964, 1, 500 feet of concrete capped steel bulkhead was constructed to complete a closure with a history of tidal flooding. For a more detailed description of these structures and their location, see Appendix G, "Prior and Existing Structures." The addition of beach fill between 14 June and 2 October 1954 along about 5, 000 feet of the southern portion of the beach was done in partial compliance with the recommended beach erosion control project authorized in 1954. This is

PHOTO 8. Nantasket Beach, 20 August 1966 - Metropolitan District Commission Beach at a near high tide, looking south.

the only significant beach fill which has been added to the beach, at least since the early part of the century. Losses of material occurred at the time of construction, possibly hurricane "Carol" 21 August 1954 caused some of the losses. Serious storms have caused further losses and grading of material from the backshore to the foreshore.

(2) At Nantasket Beach, since the early 19th century, numerous inns, cafes and amusement centers existed and extended on piles over the high water line. Wooden bulkheads limited the tidal flow under the main parts of the structures. Since around 1900, these old wooden structures have been progressively removed and wooden bulkheads replaced by massive concrete walls which extend along the entire beach backshore except at the northerly end where rock revetment is fronted by a wide, flat beach. The problem has been one of continuing erosion of beach fill during northeast storms. Various degrees of wall deterioration occur where ordinary high tides reach or approach the wall. The narrowness of the beach during ordinary high tides also seriously impairs the recreational use of the beach. The construction of massive concrete walls and redevelopment of the area by replacing former flood-prone structures with recreational facilities and parking areas has greatly reduced tidal flooding and wave damages. The few structures owned by the Metropolitan District Commission, such as comfort stations, a bathhouse and concert center, fronted by massive walls, are protected from the brunt of the wave forces. For descriptive details and location of structures, see Appendix G, "Prior and Existing Structures."

c. Beach Profiles. Hydrographic surveys for Revere and Nantasket Beach were made by the U. S. Army Corps of Engineers in 1945-46 and 1962-63. Beach profiles made from these surveys are shown on Plates 5 through 11.

(1) Revere Beach has 16 comparative profiles numbered in ascending order from north to south. These profiles, to some degree, reflect the shore processes during this period. A study of past profiles included in the cooperative beach erosion control report completed in 1949 indicates a similar trend since 1910. Above mean high water, the backshore slopes are very much steeper than the nearshore below mean low water. They range from 1 vertical on 8 horizontal to 1 vertical on 25 horizontal above mean low water to as flat as 1 vertical on 60 horizontal to 1 vertical on 100 horizontal below

mean low water. Accretion in various stages occurs throughout, above the mean low water line, while erosion is observed throughout the offshore profiles along the center section of the beach. The offshore profiles at each extremity of the beach indicate accretion except at the extreme northerly section where the influence of the tidal currents at the mouth of the Saugus River is experienced, resulting in some erosion.

(2) Nantasket Beach has 7 comparative beach profiles covering the period from 1945 - 1963. The beach is comparatively steep above the mean high water line, ranging from 1 vertical on 3 horizontal to 1 vertical on 17 horizontal. Slopes flatten out appreciably from mean high to mean low water, averaging about 1 vertical on 50 horizontal. Below the mean low water line, however, they flatten to 1 vertical on 100 horizontal or flatter. In general, a comparison of profiles indicates a history of erosion throughout the entire beach in decreasing amounts from south to north. The 1946 beach slopes also in general parallel the 1963 profiles. Apparently beach material moves on and offshore. The backshore is steepened by coarse sand and rock deposits during high level storms while the fines are carried in suspension and move offshore.

d. Volumetric Accretion and Erosion. A study of volumetric changes has been made for both beaches. This includes volumetric computations for Revere Beach from 1900 through 1962. For Nantasket Beach, it is computed for the period from 1946 through 1963, based on surveys conducted by the U. S. Army Corps of Engineers. The landward limit utilized for computations for both beaches is the seaward face of seawalls; the seaward limit for Revere was the 1900 mean low water line for comparative purposes, including information from the 1949 Corps study. The seaward limit for Nantasket Beach was to 12 feet below mean low water.

(1) A tabulation of volumetric changes for Revere Beach is shown in Table II. This best portrays the movement of beach material along the shorefront and, combined with field observation, offers practical and valuable information for the design of the beach, including consideration of groin structures to compartment the fill and their location. A study of the table indicates that in the earlier years of record, 1900 through 1910, general erosion occurred in the northern sections of the beach, Profile 2 through Profile 3, and during the period between 1904 - 1910 the erosion extended in substantial amounts

TABLE II - VOLUMETRIC CHANGES - SANDFILL - REVERE BEACH

LOCATION	PERIODS OF RECORD TOTAL CHANGE IN CUBIC YARDS					
Profile No.	1900-1904	1904-1910	1910-1946	1946-1962	1900-1946	1900-1962
1 - 2	Unknown	Unknown	Unknown	+ 70, 000	Unknown	Unknown
2 - 3	- 74, 700	- 53, 400	+39, 000	+ 83, 500	- 89, 100	- 5, 600
3 - 4	- 1, 900	- 28, 600	+ 6, 600	+ 13, 500	- 23, 900	- 10, 400
4 - 6	+ 3, 600	- 7, 700	-15, 300	- 7, 000	- 19, 400	-26, 400
6 - 8	+ 3, 500	- 10, 300	- 9, 900	+ 2, 000	- 16, 700	-14, 700
8 - 10	+ 4, 800	- 23, 500	+ 6, 400	+ 4, 000	- 12, 300	- 8, 300
10 - 12	+ 3, 100	- 10, 200	- 1, 600	+ 4, 000	- 8, 700	- 4, 700
12 - 14	+ 1, 200	+ 13, 200	+12, 500	+ 28, 000	+ 26, 900	+54, 900
14 - 15	+ 1, 500	+ 15, 400	+16, 300	+ 21, 500	+ 33, 200	+54, 700
(1)	- 58, 900	-105, 100	+54, 000	+149, 500[2]	-110, 000	+39, 500[2]

(1) Summation of Profiles 2 - 15

(2) Periods 1946 - 1962 and 1900 - 1962 reflect sandfill placed by Commonwealth of Massachusetts in 1954 in partial compliance with authorized project.

along the entire northern and central sections of the beach from Profile 2 to Profile 12. Since 1910, with the exception of the area between Profiles 4 and 12, there has been large scale accretion at both extremities of the beach. Probably the most representative period of record is that of 1946 through 1962, which shows large concentrations of accretion at the extremities of the beach with very small amounts of accretion in interior sections and one erosion area between Profiles 4 and 6. The overall summary of changes throughout the period of record for the entire beach varies from a maximum net erosion of 110,000 cubic yards between 1900 and 1946 to net accretion of 39,500 cubic yards from 1900 to 1962. The latter reflects the placement of about 172,000 cubic yards of sandfill by the Commonwealth of Massachusetts in 1954. The material was pumped onto the beach from offshore in the area between Profiles 4 and 12. Computations made immediately after placement of the fill indicated a loss from this area of about 50 percent of this fill or about 90,000 cubic yards. Many of the fines moved offshore during the dredging operation. Maximum erosion which has occurred at any one sector of the beach occurred north of Profile 12 during the period 1904 - 1910 and averages about 22,000 cubic yards a year. Probably a good, average erosion figure for the beach is about 4,000 cubic yards a year, as occurred in the period 1900 -1946 in the eroding sector.

(2) The composition of Nantasket Beach has a large proportion of small cobbles mixed with fine sand which, below mean sea level, tends to bond together forming a hard-packed surface. The orientation of the beach in a general northwest-southeast direction exposes it to the direct forces of wave action from the predominant northeast storms. These storms move the fines offshore and expose the cobbles. During annual cleanup operations, these cobbles are trucked away, thus decreasing the beach level. Based on the beach profiles over the 18-year period, 1945-1963, computations show a loss of 125,000 cubic yards or about 7,000 cubic yards a year.

PART III - ANALYSIS OF THE PROBLEM

23. Shore Processes Pertinent to the Problem. The most serious storms are from the northeast through the southeast with the northeast storms having the greater frequency. The problem at both locations is primarily one of erosion of the beaches and damage to seawalls and other alongshore structures caused by wave action experienced during frequent storms when greater than normal tide

PHOTO 9. Revere Beach, 25 May 1966 - Normal tides reach and storm tides frequently overtop these massive concrete structures, resulting in serious damage.

levels allow general overtopping of the backshore. Erosion is intensified by reflection of waves breaking on the seawalls. Construction of shorefront walls, jetties and other structures protects much of the shorefront from erosion, thus minimizing or preventing alongshore movement of beach building materials. This fact and the loss of offshore islands and wearing away of hills, drumlins, which formerly supplied large amounts of glacial materials for building these beaches, play a deciding role in selection of the best method for correcting the problem.

24. The shorefront of the Revere Beach area is subjected to erosion processes complicated by factors such as the shorefront configuration and variable offshore hydrography. The northeast storms cause waves to be refracted and diffracted around the Nahant tombolo passing over complex shoal areas. The southeast storms approach directly but are affected to a great degree by the shoal areas. A study of historical data relating to sand movement coupled with field observations disclose concentrated areas of wave attack at two segments where massive concrete stepped or apron walls have been constructed. Normal high tides reach the base of the walls. During frequent storms with higher flood levels, waves breaking on the walls reflect, causing scouring and increased losses from the backshore. The most serious section experiencing waves breaking on massive walls is just north of Eliot Circle where substantial offshore movement and some alongshore drift occur. The other section is just south of Northern Circle where similar processes, probably to a somewhat lesser degree, occur. The fineness of the existing beach material and fine material used in partial completion of the authorized project is sensitive to rapid movement by wave-induced processes occurring during frequent storms. The natural flat slope of this fine material results in large horizontal movement of the bottom contours for small vertical changes. The tidal influence of the Saugus River at its mouth and navigation entrance channel plays an important role in sand movement and distribution at the northern extremity of the beach. The littoral movement of sand is restricted from passing across the channel in a large part either from the beach or from the tidal flats to the northeast to any degree. The Roughan's Point headland, largely protected by concrete walls and revetment, and the Cherry Island breakwater also have an appreciable effect on the wave forces and related processes. The beach, in effect, is a self-contained unit

between Roughan's Point on the south and the mouth of the Saugus River to the north. Therefore, very little beach building material is added to the beach from outside sources, although a very small amount of gravelly material may be added to the rocky southern shore from the Cherry Island bar. The material on the beach is, therefore, subjected to some redistribution laterally along the beach, combined with offshore and onshore movement occurring during destructive high level storms or wave building swells.

25. The location and orientation of Nantasket Beach become very important factors in related shorefront processes affecting the beach. The beach is oriented in a nearly northwest-southeast direction, in effect normal to the approach of the more frequent and serious northeast storms. These are the storms which provide the greatest energy producing destructive forces for erosion of the beach. The geological construction of the beach was accomplished by the erosion and loss of several offshore islands and the tying together of islands forming a complex tombolo. This process has long since been completed; there is apparently very little material for beach building processes and presently the beach is in a state of retrogradation. Without the addition of beach nourishment, the beach will continue to diminish in size. The composition of the beach is hardpacked, very fine sand mixed with a generous proportion of small stones or cobbles. The action of storm-induced waves places the fines in suspension, moving them offshore, adjusting to a very flat slope. The cobbles which are left on the beach are removed during annual cleanup. The combination of these manual and natural factors produces serious losses and general lowering of the beach to the extent that even during normal high tides there is little or no protective and recreational beach, with the tide reaching the base of the seawalls and extending along the backshore in some sections of the beach. Field observations for the area verify findings that there is an absence of any predominant littoral drift.

26. Methods of Correcting Problem Conditions. The natural and most economical type of construction is by replacing the sand which is lost. This can best be accomplished by artificial placement of suitable sandfill on the beaches, providing a beach berm commensurate with natural berm widths found to be stable within the area. This, in effect, will provide a higher and wider beach, furnishing protection to shore structures from wave damage experienced during the more frequent storms by causing waves to break seaward of the structures.

PHOTO 10. Nantasket Beach, 4 March 1966 - Serious storms frequently deposit cobbles along backshore.

Material is probably available offshore or in portions of tidal inlets. However, past experience has found that this material is likely to be quite fine and if used as beach fill is subject to substantial offshore losses. A well graded land-source material, trucked in for both beaches, would be the most practical method, considering stability of the beaches and future maintenance requirements. However, offshore investigation for selected beach fill material should be accomplished before or at the time of final project design. The offshore areas selected for investigation will be delineated as a result of the offshore sand inventory program completed for the New England Coast in 1968 under the supervision of the Coastal Engineering Research Center, Corps of Engineers. The projects would then be constructed utilizing either land sources and trucking operations or by onshore pumping operations or a combination thereof. Nantasket Beach, due to its orientation with respect to the serious northeast storms, is more susceptible to larger offshore losses than Revere Beach. At Revere, although substantial offshore movement of the finer material can occur, the problem is intensified somewhat by some littoral movement of this fine material which may, even with a better graded beach fill than exists, require groin structures at critical locations to minimize the alongshore movement reducing nourishment requirements and to maintain the width and alignment of the improvement.

27. Design Criteria. Proposed improvement measures are designed to serve the dual purpose of furnishing an adequate recreational beach for present and future use and to provide protection for ordinary storm conditions of comparatively frequent occurrence (about once a year). They are not intended to provide complete protection in the event of hurricanes or great storms of infrequent occurrence, although even under these conditions some protection will be afforded. More detailed information on items, as discussed below, is furnished in Appendix K, "Design Analysis."

a. Design Tide. The design tide is the highest tide which occurs on an average of about once a year. The elevation of the design tide above the plane of mean high water is 3.0 feet at Revere (12.0 feet above mean low water) and 3.0 feet at Nantasket (12.4 feet above mean low water). The highest tide of record at Boston, Massachusetts, was observed as 14.2 feet above mean low water during the winter storm of 29 December 1959.

b. Design Wave. The height of the design wave was determined from the relationship d/H = 1.28, where d is the depth of water at or slightly seaward of the proposed structure at the time of design tide and H is the highest wave that can be sustained before breaking.

c. Sizes and Slopes of Armor Stones in Structures. Sizes and slopes of armor stones for groins are computed using the United States Army Waterways Experiment Station stability formula as described in EM 1110-2-2904, dated 30 April 1963, entitled "Engineering and Design, Design of Breakwaters and Jetties."

d. Sandfill. The berm widths and beach slopes are based on those found to be stable within the area and to provide sufficient width and depth over massive stepped or sloped concrete seawalls to minimize losses from scouring during infrequent storms of greater than design flood level when the beach is overtopped. The fill will be obtained from either a suitable land source or from an offshore borrow area as delineated by the offshore sand inventory survey completed for the New England coastal area in 1968 under supervision of the Coastal Engineering Research Center, Corps of Engineers, Washington, D. C. Suitable fill would be somewhat better graded than the existing beach materials for more stable beach construction. For the purpose of detailed design of beach fills, the investigations of materials on the beaches and in proposed borrow areas must be supplemented when plans and specifications are being prepared.

e. Groins. Groin structures have been considered for Revere Beach for compartmenting the beach fill and maintaining beach width and alignment within the two areas with a history of erosion and concentrated wave attack. These areas are observed to be sensitive to littoral movement of existing fine material; however, a better graded material for beach construction should be much less susceptible to movement. Eight groins, four in each area, have been included in a studied plan. The structures vary from about 410 feet in length to 615 feet, extending through the beach berm to just seaward of the designed toe of beach fill. They would have a smooth top surface for use of fishermen to near normal high tide.

PART IV - PROJECT FORMULATION

28. Prior studies for Revere and Nantasket beaches recommended beach widening for Revere Beach and concluded that Nantasket Beach was satisfactory if protective structures were properly maintained. The restudy of these beaches has found it appropriate to modify these conclusions. In the project formulation, consideration was given to beach berms of varying widths to determine the most practical and economical plan of improvement. In order to realize the optimum plan, consideration was given to the minimum width needed to provide reasonably stable conditions against the wave action expected, thus avoiding the possibility of continued damage to seawalls and increased loss of beach fill if waves of substantial size were to break frequently on the walls. Widths greater than those selected would not be economically desirable. The selected plans of improvement for the beaches are as discussed in the following paragraphs.

PART V - PLANS OF IMPROVEMENT

29. Plans of Improvement - Revere Beach. The most natural and practical type of protection is by sand replenishment, providing a berm and beach slopes similar to existing stable conditions within the area and assuring sufficient depth and width of material at massive concrete sections which slope seaward to reduce wave heights and minimize losses of fill at the wall during occasions when overtopping of the berm occurs. In the light of the experienced losses occurring following the partial construction of the authorized project and in accordance with the desires of local interests who believe that groin structures should be considered for Revere Beach, two plans of improvement are studied --one by beach widening without retention structures and one with groin structures. The plans are described as follows:

a. PLAN 1. Widening about 13,000 feet of beach by placement of suitable sandfill (better graded material than utilized in the partial construction of the authorized project) to a general backshore elevation of 18.0 feet above mean low water, providing a protective and recreational beach of about 185 feet in width behind the mean high water line. See Plates 19 and 20 for details.

b. PLAN 2. Providing the same beach as for Plan 1 and including 8 strategically located rock groin structures, 4 at the concentrated damage area just north of Eliot Circle and 4 just south of Northern Circle. The groins vary between about 410 feet and 615 feet in length, spaced about 1,200 feet apart. See Plates 17 and 18 for details.

30. Plan of Improvement - Nantasket Beach. The natural and practical type of protection is, as for Revere Beach, by restoration of the beach to adequate size similar to existing stable conditions within the area, by replenishment of suitable beach sand. The plan of protection consists of widening the beach to a general width of about 190 feet behind the mean high water line, to a backshore elevation of 17 feet above mean low water. See Plate 21 for details.

PART VI - ECONOMIC ANALYSIS

31. General. Detailed estimates of costs and annual charges are included in Appendix I and detailed estimates of benefits are presented in Appendix J. Cost estimates are based on the prevailing 1968 price level.

32. First Costs. The first cost of the projects is based on sandfill and armor stone being obtained from land sources. The unit cost is considered as conservative, realizing that some degree of economy might be experienced utilizing techniques of onshore pumping procedures presently being developed by the Corps of Engineers. The Federal participation in the first costs of the projects is computed at 50 percent. The first costs of the projects are tabulated below:

Project	Work Item	Total First Cost	Federal & Non-Federal Share 50%
Revere Beach (Plan 1)	Sandfill	$2,400,000	$1,200,000
Revere Beach (Plan 2)	Sandfill and 8 groins	$3,250,000	$1,625,000
Nantasket Beach	Sandfill	$2,000,000	$1,000,000

33. Annual Charges. The Federal investment cost for both projects is computed at fifty percent of the first cost of construction. An interest rate of 3-1/4% and a useful project life of fifty years are used for the determination of amortization charges. In estimating losses for both beaches, consideration has been given to past losses as determined from a study of beach profiles, their structural makeup, including compaction and some degree of cohesiveness and allowing for the placement of a less compacted fill extending above and seaward of the existing beach. On this basis, annual charges are included sufficient to provide periodic nourishment of both beaches of 20,000 cubic yards. This about equals 5 times the loss of natural beach in the eroding section of Revere Beach as determined for the period of 1900-1946 and about three times the computed loss

of natural fill at Nantasket Beach which is more compacted than at Revere Beach. For consideration of groin construction at Revere Beach, it is conservatively estimated that the periodic nourishment requirements might be reduced by fifty percent or 10,000 cubic yards per year. Fifty percent Federal participation in periodic nourishment is allowed based on the possibility that even with a better graded material experience could show their need to maintain project width and alignment.

34. For details of the annual charges, see the tabulation below:

ANNUAL CHARGES

Revere Beach - Plan 1

Item	Federal	Non-Federal	Total
Interest 6 7/8% 0.06875	$39,000	$39,000	$ 78,000
Amortization 0.002569	9,900	9,900	19,800
(1) Periodic Beach Nourishment	25,000	25,000	50,000
Total	$73,900	$73,900	$147,800

Revere Beach - Plan 2

Interest	$52,800	$52,800	$105,600
Amortization	13,400	13,400	26,800
Maintenance Groins	---	6,500	6,500
Periodic Beach Nourishment	12,500	12,500	25,000
Total	$78,700	$85,200	$163,900

Nantasket Beach

Interest	$32,500	$32,500	$ 65,000
Amortization	8,200	8,200	16,400
(1) Periodic Beach Nourishment	25,000	25,000	50,000
Total	$65,700	$65,700	$131,400

(1) This Federal share would be for the first 10 years of project life, after which benefits and techniques would be reevaluated.

35. Benefits. Revere Beach and Nantasket Beach are each within easy commuting distance from the heavily populated Metropolitan Boston area. It is reported by the Metropolitan District Commission that as many as 14, 000, 000 people visit Revere Beach annually, with a peak day attendance of as many as 200, 000. The Commission reports that Nantasket Beach is similarly popular. Not all of the attendants utilize the beaches. Many enjoy the amusements or are strictly sight-seeing. The recreational benefits for both beaches are based on providing an economically feasible beach of adequate capacity during normal high tide for present and future use. For Revere Beach, this would provide for comfortable beach use at normal high tide of about 60, 000 bathers and at Nantasket about 30, 000. The present attendance at both these areas and inadequate size of the existing beaches more than justify the proposed projects. The construction of these beaches will act as an added attraction to these areas, encouraging continuing local and tourist visitation. In addition to providing recreational benefits, the beach widening will furnish protection to existing shorefront structures from wave damages occurring during ordinary storms, substantially reducing present annual maintenance costs for these structures.

36. For details of the annual benefits, see the tabulation below:

ANNUAL BENEFITS

Project	(1) Recreational	(2) Direct Damages Prevented	Total
Revere Beach	$ 570, 000	$50, 000	$ 620, 000
Nantasket Beach	392, 250	25, 000	417, 250

(1) $0. 75 per bather day. Some overcrowding may occur on peak days but no additional benefits are taken.

(2) Based on past maintenance costs by Commonwealth of Massachusetts and allowing for a substantial reduction in costs.

37. Interests. There are no direct interests to the United States as a landowner, since none of the shore is owned by the United States. Non-Federal public interest is defined as:

a. The benefits accruing to a State or political subdivision thereof, as a landowner.

PHOTO 11. Nantasket Beach, 15 August 1965 - This is typical of crowded conditions here on any good bathing day.

PHOTO 12. Revere Beach, 20 August 1966 - Bathers utilize concrete apron during a normal high tide.

b. The benefits accruing to the general public through public use of either public or private property or from protection of nearby public property.

38. Private interest is defined as the benefits derived by individuals or non-public groups of individuals on account of ownership of lands and business enterprises affected. All estimated benefits resulting from this project are classified as non-Federal public benefits.

39. Justification. The estimated annual benefits and costs and the resulting ratio of benefits to costs for the project are given below:

Project	Estimated Annual Benefits	Estimated Annual Costs	Ratio of Benefits to Costs
Revere Beach - Plan 1	$ 620,000	$147,800	4.2
[1]Revere Beach - Plan 2	620,000	163,900	3.8
Nantasket Beach	417,250	131,400	3.2

[1]This plan, utilizing groin structures as a measure of reducing periodic nourishment requirements, based on available data, determines that groin structures are not the most economical solution.

40. Apportionment of Costs. The policy of Federal aid for restoration and protection against erosion of the shores of the United States, its territories and possessions, was established by Public Law 826, 84th Congress, as amended by Public Law 87-874 (River and Harbor Act of 23 October 1962). Federal participation in the cost of construction of a project for a non-Federal, publicly-owned shore (not a park or conservation area) is limited to a maximum of one-half the total cost. No Federal contribution toward maintenance is authorized but a maximum Federal participation of fifty percent of the cost of periodic nourishment for a non-Federal, publicly-owned beach may be authorized for a length of time specified by the Chief of Engineers. Both the Revere and Nantasket projects are not natural conservation or park areas fronted by natural dunes and protective bluffs and, therefore, qualify for the maximum fifty percent Federal contribution in the cost of construction and fifty percent of the cost of periodic nourishment to be effected by depositing sand on the beach at suitable intervals of time for an initial period of ten years from the year

of completion of the projects. The period of Federal aid in periodic nourishment is limited to ten years in order to evaluate methods, benefits and techniques based on experience gained with the constructed improvement. The intent is not to discontinue Federal cooperation in an improvement but to be assured that the most economical procedure for maintaining the project is utilized. The apportionment of costs for the most economical plan of improvement, Plan 1 for Revere Beach, and for the plan of improvement for Nantasket Beach is itemized in Table III.

41. Coordination and Comments of Other Agencies and Local Interests. Close coordination has been maintained with other agencies during the course of the study. The Metropolitan District Commission, the cooperative agency, stated that, after consideration and a full discussion of the projects, the Commission approves the plans as developed in the study and will participate in the cost of construction of the projects. See Appendix L, "Report of the United States Fish and Wildlife Service, and comments of the Metropolitan District Commission."

42. The placement of fill on the beaches would not significantly affect fish and wildlife resources. For a full report, see Appendix L, "Report of the United States Fish and Wildlife Service and Comments of the Metropolitan District Commission," which was made in cooperation with the Massachusetts Division of Fisheries and Game and the Massachusetts Division of Marine Fisheries. Pertinent comments from these reports are as follows:

a. Revere Beach. Placement of fill on the beach would not significantly affect fish and wildlife resources. Neither would dredging for fill offshore or from the mouth of the Saugus River significantly affect these resources, nor would trucking in the fill material. Dredging in the Pines River, however, would cause the loss of soft clam resources and losses of important waterfowl habitat. Groins constructed to deep water would provide sport fishing opportunities.

b. Nantasket Beach. Placement of fill on the beach and construction of groins would not cause significant fish and wildlife resource losses. Neither would dredging offshore of Nantasket Beach or in the Weir River channel or trucking in fill materials cause significant resource losses. Dredging in the interior marshes or flats, however, would cause significant losses of waterfowl habitat.

TABLE III - Apportionment of First and Annual Costs

Item	Federal Percent	Federal Amount	Non-Federal Percent	Non-Federal Amount	Total Percent	Total Amount
(1) (3) First Cost - Plan 1, Revere Beach						
Beach Restoration	50	$1,200,000	50	$1,200,000	100	$2,400,000
Annual Cost - Plan 1, Revere Beach						
Interest	--	39,000	--	39,000	---	78,000
Amortization	--	9,900	--	9,900	---	19,800
(2) Periodic beach nourishment	50	25,000	50	25,000	100	50,000
Total Annual Cost		$ 73,900		$ 73,900		$ 147,800
(3) First Cost - Nantasket Beach						
Beach Restoration	50	$1,000,000	50	$1,000,000	100	$2,000,000
Annual Cost - Nantasket Beach						
Interest	--	32,500	--	32,500	---	65,000
Amortization	--	8,200	--	8,200	---	16,400
(2) Periodic beach nourishment	50	25,000	50	25,000	100	50,000
Total Annual Cost		$ 65,700		$ 65,700		$ 131,400

(1) This is most economical plan for Revere Beach. For details on apportionment for Plan 2, see Appendix I, "Estimates of Cost of Improvements."

(2) This Federal share would be for the first 10 years of project life, after which benefits and techniques would be reevaluated.

(3) Exclusive of preauthorization cost of $20,000 for each beach.

PART VII- CONCLUSIONS AND RECOMMENDATIONS

43. Conclusions. The Division Engineer concludes that the most practical and economical method of protection and restoration of the beaches is as shown on Plates 19 and 20 for Revere Beach, Plan 1, and on Plate 21 for Nantasket Beach, described as follows:

a. Revere Beach. In lieu of the authorized project, provide beach widening by placement of suitable sandfill along about 13,000 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a recreational and protective beach averaging 185 feet in width behind the mean high water line, an increased width over the authorized project commensurate with present and long-range comfortable recreational use requirements and providing a more effective protective improvement fronting massive concrete stepped walls and structures. A better graded fill would be utilized than was used in the partial construction of the authorized project.

b. Nantasket Beach. Provide beach widening by placement of suitable sandfill along about 6,800 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 17 feet above mean low water, thus furnishing a recreational and protective beach width averaging 190 feet behind the mean high water line.

44. The Division Engineer further concludes that periodic nourishment of the beaches qualifies for Federal participation in the cost of depositing sand at suitable intervals of time for an initial period of ten years. After the first 10 years of project life, benefits and techniques would be reevaluated.

45. Recommendation. The Division Engineer recommends that beach erosion control projects be adopted for Revere and Nantasket Beaches authorizing Federal participation to the extent of one-half the cost of construction of the projects, with the initial construction to be by the United States, described as follows:

a. Revere Beach. In lieu of the project authorized by the River and Harbor Act of 1954, provide beach widening by direct

placement of suitable sandfill along about 13, 000 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a recreational and protective beach averaging 185 feet in width behind the mean high water line, an increased width over the authorized project commensurate with present and long-range comfortable recreational use requirements and providing a more effective protective improvement fronting massive concrete stepped walls and structures.

b. Nantasket Beach. Provide beach widening by direct placement of suitable sandfill along about 6, 800 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 17 feet above mean low water, thus furnishing a recreational and protective beach averaging 190 feet in width behind the mean high water line.

46. The Division Engineer further recommends that Federal participation be authorized for both projects in the amount of one-half the cost of periodic nourishment by depositing sand on the beaches at suitable intervals of time for the first 10 years of project life, the periodic nourishment to be by the United States after receipt of the local share.

47. The presently estimated first cost of the projects is $2, 400, 000 for Revere Beach, and $2, 000, 000 for Nantasket Beach, to be borne jointly by the United States and the Commonwealth of Massachusetts. The Federal share of the construction cost of the projects is established at fifty percent or $1, 200, 000 for Revere Beach, and $1, 000, 000 for Nantasket Beach. The estimated annual amount of Federal participation for periodic nourishment at each beach is $25, 000.

48. The recommended Federal participation is subject to the conditions that local interests will:

a. Contribute in cash 50 percent of the cost of construction of the projects, such contributions presently estimated at $1, 200, 000 for Revere Beach and $1, 000, 000 for Nantasket Beach.

b. Contribute in cash 50 percent of the periodic nourishment cost for each beach for an initial period of ten years, now estimated at $25, 000 annually, such contributions to be prior to each nourishment operation.

c. Assure the continued performance of the periodic nourishment and repair of the projects after the first ten years and during the economic life as may be required to serve the intended purpose.

d. Assure that water pollution that would endanger the health of bathers will not be permitted.

e. Hold the United States free from damages due to construction of the project.

f. Provide at their own expense all necessary lands, easements and rights-of-way for the initial construction and subsequent nourishment of the projects.

g. Assure continued public ownership of the shore and its administration for public use during the economic life of the project.

34 Incl
13 Appendices
21 Plates

REMI O. RENIER
Colonel, Corps of Engineers
Division Engineer

APPENDIX A

DESCRIPTION AND COMPOSITION OF BEACHES

1. General. Detailed descriptive data concerning the shoreline was obtained by field inspections. Descriptions of the shore are included in the subparagraphs below. Revere Beach is described in geographic sequence from Eliot Circle to Point of Pines. Nantasket Beach is described in geographic sequence from Atlantic Hill to Phipps Street. Surface samples of beach and nearshore material were obtained in the coastal area on selected profiles. Results of analyses of these samples are included in Appendix C. Locations of profiles are shown on Plates 2-4, inclusive.

I. Revere Beach

a. Eliot Circle

(1) Location: South limit of the study area.

(2) Shore Length: 500 feet.

(3) Beach width Above H. W.: Narrow sand beach (50 feet in width). Water line during spring tides and above reaches concrete wall fronting Eliot Circle.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: None.

(6) Composition of Shore: Shore is covered with small stones.

(7) Protective Structures: Concrete wall around the circle.

(8) Character of Development: Traffic circle feeding shorefront road from Revere Beach Parkway and Winthrop Parkway.

b. North of Eliot Circle:

(1) Location: Immediately north of Eliot Circle to pavilion at Shirley Avenue.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H.W.: Varies from 50 feet or less in width in front of Eliot Circle to about 200 to 250 feet, 1,000 feet north of Eliot Circle back to a width of about 10 feet in front of the pavilion near Shirley Avenue.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Sanitary facilities building located halfway between Cove St. and Shirley Avenue. Pavilion fronting Shirley Avenue and Beach Street.

(6) Composition of Shore: Sand ranging from fine to gravelly.

(7) Protective Structures: There are no protective structures other than the pavilion, which is fronted by concrete.

(8) Character of Development: Commercial establishments on landward side of shore road.

c. Between Eliot Circle and Northern Circle.

(1) Location: Pavilion at Shirley Avenue to Pavilion at Bath House.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H.W.: Between the pavilions the beach width is 15 feet. There is no beach fronting the pavilion at the bathhouse.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Bathhouse north of Chester Avenue Pavilion across the street from bathhouse.

(6) Composition of Shore: Shore is covered with small stones.

(7) Protective Structures: Concrete parapet wall along sidewalk. Pavilion at bathhouse is fronted by concrete with a concrete apron.

(8) Character of Development: Amusement area on landward side of shore road.

(d) Between Eliot Circle and Northern Circle:

(1) Location: Pavilion at Bathhouse to Pavilion at Revere Street.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H. W.: No sand beach. Water line reaches concrete apron at high water.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Pavilion at Revere Street.

(6) Composition of Shore: Sand is fine below high water line.

(7) Protective Structures: Concrete parapet wall along sidewalk. Concrete apron fronting wall between pavilions. Pavilion fronted by concrete.

(8) Character of Development: Amusement area on landward side of shore road.

e. Between Eliot Circle and Northern Circle:

(1) Location: Pavilion at Revere Street to Pavilion at Oak Island Street.

(2) Shore Length: 2,000 feet.

(3) Beach Width Above H. W.: Beach widens from 0 feet at Revere Street Pavilion to about 160 feet at Oak Island Street Pavilion.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Pavilion at Oak Island Street.

(6) Composition of Shore: Shore is composed of fine sand which is being wind-blown and piled up against wall.

(7) Protective Structures: Curb wall along sidewalk. Pavilion at Oak Island Street fronted by concrete.

(8) Character of Development: Residential on landward side of shore road.

f. Between Eliot Circle and Northern Circle:

(1) Location: Pavilion at Oak Island Street to concrete stepped wall.

(2) Shore Length: 3,400 feet.

(3) Beach Width Above H. W.: Beach varies from about 160 feet at the pavilion to 0 feet at the concrete stepped wall.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Sanitary facilities building located about 1300 feet north of Oak Island Street.

(6) Composition of Shore: Shore is composed of some small stones and fine sand. The sand is being wind-blown and piled up against wall.

(7) Protective Structures: Concrete parapet wall along sidewalk. Dumped riprap on the northerly 250 feet of this section.

(8) Character of Development: Residential on landward side of shore road.

g. Between Eliot Circle and Northern Circle:

(1) Location: Concrete Stepped Wall.

(2) Shore Length: 1,500 feet.

(3) Beach Width Above H. W.: No sand beach. Water line reaches concrete stepped wall.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand between wall and low water line.

(7) Protective Structures: Concrete parapet wall along sidewalk fronted by concrete stepped sea wall.

(8) Character of Development: Residential on landward side of shore road.

h. Between Eliot Circle and Northern Circle:

(1) Location: Between concrete stepped wall and Northern Circle.

(2) Shore Length: 900 feet.

(3) Beach Width Above H. W.: Wedge shaped, zero width at concrete stepped wall to about 20 feet at widest point.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand, some small stones.

(7) Protective Structures: Curb wall along sidewalk. Dumped riprap on the southerly 125 feet of this section.

(8) Character of Development: Residential on landward side of shore road.

i. Northern Circle:

(1) Location: Front of Northern Circle.

(2) Shore Length: 250 feet.

(3) Beach Width Above H. W.: 20 feet at start of circle to zero feet in the center of the circle.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand, some small stones.

(7) Protective Structures: Concrete wall around the circle.

(8) Character of Development: Residential on landward side of the circle.

j. Point of Pines:

(1) Location: Northern Circle to Harrington Avenue.

(2) Shore Length: 400 feet.

(3) Beach Width Above H. W.: No sand beach.

(4) Ownership: Private.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand below high water line.

(7) Protective Structures: Rip rap revetment.

(8) Character of Development: Residential on landward side of shore road.

k. Point of Pines:

(1) Location: North limit of the study area.

(2) Shore Length: 2600 feet.

(3) Beach Width Above H. W.: Beach varies from zero feet at Harrington Avenue to 200 feet at the northern end of the area.

(4) Ownership: Private.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand.

(7) Protective Structures: 400 feet of precast concrete wall fronted by riprap between Harrington Avenue and Chamberlain Avenue

450 feet of concrete wall between Chamberlain Avenue and Alden Avenue. Concrete wall along northerly 500 feet of area.

(8) Character of Development: Residential on landward side of shore road. Dunes on backshore of beach. Beach is posted as private.

II. Nantasket Beach

a. Atlantic Hill

(1) Location: South limit of the study area.

(2) Shore Length: 400 feet.

(3) Beach Width Above H.W.: Beach varies from 100 feet at south limit of reservation to 30 feet at the edge or first stairwell.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: None.

(6) Composition of Shore: Fine sand covered by small stones.

(7) Protective Structures: Concrete wall back edge of beach.

(8) Character of Development: Commercial and amusements on landward side of shore road.

b. North of Atlantic Hill

(1) Location: First stairwell to jog in wall at concert hall.

(2) Shore Length: 1500 feet.

(3) Beach Width Above H.W.: About 10 feet.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Comfort station approximately 1200 feet north of south limit of reservation. Concrete platform with fixed benches about 200 feet north of comfort station.

(6) Composition of Shore: Fine sand covered with small stones.

(7) Protective Structures: Concrete wall back edge of beach.

(8) Character of Development: Amusement area on landward side of shore road.

c. Center of Reservation:

(1) Location: Concert Hall to bathhouse.

(2) Shore Length: 900 feet.

(3) Beach Width Above H. W.: None.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Concert Hall approximately 1800 feet north of south limit of reservation. Bathhouse about 500 feet north of concert hall.

(6) Composition of Shore: Fine sand covered with small stones.

(7) Protective Structures: Concrete wall back edge of beach.

(8) Character of Development: Amusement area on landward side of shore road.

d. Center of Reservation:

(1) Location: Bathhouse to end of concrete wall.

(2) Shore Length: 2700 feet.

(3) Beach Width Above H. W.: About 10 feet.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Comfort station approximately 2800 feet north of south limit of reservation.

(6) Composition of Shore: Fine sand covered with small stones.

(7) Protective Structures: Concrete wall back edge of beach.

(8) Character of Development: Commercial and amusement area on landward side of shore road.

e. North Section of Reservation:

(1) Location: End of concrete wall to north limit of reservation.

(2) Shore Length: 1300 feet.

(3) Beach Width Above H. W.: Beach varies from about 10 feet at wall to about 150 feet at end of project.

(4) Ownership: Metropolitan District Commission.

(5) Public Facilities: Comfort station approximately 200 feet south of Phipps Street.

(6) Composition of Shore: Fine sand covered with small stones.

(7) Protective Structures: Riprap starting at end of concrete wall extending 500 feet to the north.

(8) Character of Development: Residential on landward side of shore road.

APPENDIX B

GEOMORPHOLOGY

1. General Geology. Till is the oldest surficial deposit in the area, although it is much younger than the bed rock on which it rests. Sea level stood at approximately its present position shortly after the deposition of the till and the recession of the ice. Following a short interval at this stand, sea level dropped slowly to a point scores of feet lower than the present position. After a period of unknown length, the sea rose from this low level and the shoreline moved westward.

2. Coastal Geology of the Revere Area. Revere Beach is a barrier beach separating the Lynn tidal marshes from the ocean. After the consecutive deposition of till, outwash, and clay upon bedrock and the dropping of the sea level, the Saugus and other rivers ran across the clay, and in places silt, sand, and gravel were deposited. As sea level rose, the beaches that had formed moved landward. The first beach to occupy an area close to the present Revere Beach probably terminated approximately 4,000 feet south of the tip of Point of Pines. Following this the beach grew northward. Lynn Beach was probably in existence at this time, and its presence decreased the effectiveness of the northeast storms, and made it easier for Revere Beach to grow northward. The growth of Revere Beach in this direction no doubt became progressively slower, however, because of the action of the currents in Saugus River.

3. The greater width of the northern end of Revere Beach is due to a number of factors. A succession of hooks grew northward and westward. Their orientation suggests that the beach south of the first-formed hooks has retrograded, and this in turn caused the northern end of the beach to prograde southeastward. The area between the hooks has been filled in by marsh and artificially placed land deposits. The narrowness of the beach south of Point of Pines indicates that only a limited amount of beach material has been supplied from the various sources.

4. Geologically, Revere Beach is in a general way stabilized by: (1) Beachmont and Cherry Island Bar, (2) deposits east of Oak Island, Young's Hill, and Revere Street; (3) current action in the Saugus River; (4) the protective influence of Lynn Beach and Nahant; (5) shallow water in Broad Sound.

5. Coastal Geology of the Nantasket Area. Nantasket Beach extends from Atlantic Hill at the southeast to Point Allerton on the northwest, a

distance of approximately $3\frac{1}{2}$ miles. It varies in width from about 500 feet to approximately one-half mile. In the growth of Nantasket Beach several drumlin (glacial hill) islands were tied by beaches to the mainland at Atlantic Hill. Such a feature is called by many authorities a complex tombolo.

6. When the sea level stood at its present level after the deposition of till and recession of ice, Strawberry Hill and other drumlins were islands. After the sea level dropped, they were connected with the mainland. As the sea level rose once again, the drumlins again became islands. Those east of the present Nantasket Beach were eroded and a series of connecting beaches were formed. Later, when the sea stood at or near its present position, the remaining drumlins were cliffed and the western side of Nantasket Beach was formed. From the geological point of view, little or no natural fill material will be added to Nantasket Beach.

APPENDIX C

SAMPLES OF BEACH AND NEARSHORE MATERIAL

1. Samples of nearshore and surface materials were obtained at Revere Beach and Nantasket Beach at specified locations. A mechanical analysis was run of each sample and the results are included in tables following this appendix. Information of the location of the samples, range of grain sizes, median diameters, character of material in percent, cumulative weight percentages retained on various sieves for individual samples and for the average of all samples of each profile is included. In addition, sorting and skewness characteristics of the beach material are included.

2. Statistical Parameters. The three statistical parameters employed to express the characteristics of the size distribution are the median diameter, the coefficient of sorting and the skewness. All of these parameters are derived from the cumulative size distribution curves and are listed in Tables C-1 and C-3.

a. Median Diameter. The median diameter (Md) in millimeters is the mid-point of the grain size diameters contained in the sample. Fifty percent of the total weight of the sample is composed of particles with a diameter greater than, and fifty percent is smaller than the median diameter.

b. Coefficient of Sorting. The coefficient of sorting (So) is a measure of the spread in grade sizes represented in the sample of the littoral material. If there is perfect sorting, the value of So would be unity. A value of 1.25 in the beach material, and 1.45 for material from the nearshore bottom is indicative of good sorting.

c. Skewness. The skewness (Sk) is a measure of symmetry of the size distribution with respect to the median. If the value of the skewness is unity, the point of maximum sorting coincides with the median diameter; if the value is greater than unity, the maximum sorting lies on the fine side of the median diameter; and if it is less than unity, the maximum sorting lies on the coarse side of the median diameter.

3. The greater the value of the median diameter, the coarser is the material; the larger the value of the coefficient of sorting, the more poorly sorted is the material; and the more the value for skewness diverges from unity, the more unsymmetrical is the size distribution curve. Small values for both So and Sk indicate the material is in adjustment with its environment. A large value for So and a small value for Sk indicate the material is spread through many grade sizes. A small

value for So and a large value for Sk indicate that the material ranges through many grade sizes and that one set of environmental factors is dominant, though traces of others are still retained. Large values for both So and Sk indicate that the sediment is completely out of adjustment with its environment.

4. Comparison of the average median diameters for Revere Beach show a very fine material, in general, under .10mm. and .17mm. a maximum average. For Nantasket Beach, average median diameters throughout the beach are about 8mm; however, this average reflects the large amount of cobbles at the seawall and in the deeper water, 30-foot depths. A good average sand size averages about .23mm.

5. An inspection of the table indicates for Revere Beach that very fine sand is prevalent throughout. As a whole, the sorting and skewness characteristics demonstrate that the beach material is in adjustment with its environment. During serious storms which overtop the beach, this material is placed in suspension by wave action and moved offshore and alongshore, adjusting to very flat slopes. Although the beach material for Nantasket Beach is generally not as fine as for Revere, the high average value of the median diameter reflects the presence of the coarse gravel prevalent in deeper water and along the seawall at the backshore. This is indicative of the large scale movement of material onshore and offshore occurring during serious storms with separation of the fines from the cobbles and distributing them along the backshore and in the greater water depths that can support the larger waves. The skewness factor as a whole is greater than .9, approaching unity, which indicates that the sand size is about equal to the median diameter or slightly coarser. The magnitude of the coefficient of sorting in general indicates good sorting of beach material.

TABLE C-1 CHARACTERISTICS OF SAMPLES
REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
1	Berm	0.07-0.21	0.15				100		1.15	0.85
	Mean Tide	0.07-4.76	0.16		20.8	14.9	64.3		3.82	8.20
	M. L. W.	Pan-2.00	0.13			3.0	90.9	6.1	1.26	0.84
	6 Ft.	Pan-0.42	0.13				99.0	1.0	1.18	0.83
	12 Ft.	Pan-2.00	0.16			5.8	92.5	1.7	1.14	0.86
	18 Ft.	Pan-0.42	0.089				89.4	10.6	1.11	1.00
	End	Pan-0.21	0.086				90.7	9.3	1.06	1.03
	Average		0.13							
1B	Mean Tide	0.07-4.76	0.16		9.1	6.3	84.6		1.41	1.13
	M. L. W.	Pan-0.42	0.13				98.3	1.7	1.41	0.96
	6 Ft.	Pan-0.42	0.12				98.9	1.1	1.41	0.94
	12 Ft.	Pan-0.42	0.16			5.4	93.2	1.4	1.14	0.86
	End	Pan-0.21	0.09				89.0	11.0	1.12	0.99
	Average		0.13							

TABLE C-1 CHARACTERISTICS OF SAMPLES (cont'd.)
REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
2A	Mean Tide	0.074-0.42	0.15				100		1.24	0.83
	M. L. W.	0.074-0.21	0.11				100		1.20	0.97
	6 Ft.	Pan-0.42	0.083				95.1	4.9	1.16	1.07
	12 Ft.	Pan-0.21	0.083				88.0	12.0	1.16	1.07
	End	Pan-0.21	0.091				88.3	11.7	1.17	1.06
	Average		0.10							
3	Berm	0.074-0.42	0.16				100		1.22	0.84
	Mean Tide	0.074-0.42	0.19				100		1.38	0.90
	M. L. W.	Pan-0.21	0.11				95.5	0.5	1.24	1.04
	6 Ft.	Pan-0.42	0.09				97.0	3.0	1.10	1.02
	12 Ft.	Pan-0.42	0.084				83.8	16.2	1.10	0.94
	15 ± Ft.	Pan-0.21	0.086				90.5	9.5	1.06	0.97
	Average		0.12							

TABLE C-1 CHARACTERISTICS OF SAMPLES (cont'd.)
REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
4	Berm	0.074-4.76	0.22		3.1	13.4	83.5		1.33	1.19
	Mean Tide	0.074-4.76	0.18		5.0	7.4	87.6		1.26	1.11
	M. L. W.	0.074-2.00	0.17			16.3	83.7		1.47	1.08
	6 Ft.	Pan-2.00	0.091			1.2	89.6	9.2	1.16	1.09
	12 Ft.	Pan-0.42	0.091				95.2	4.8	1.10	1.00
	End	Pan-0.21	0.12				99.0	1.0	1.32	1.02
	Average		0.15							
7	"G"	Pan-2.00	0.094			3.0	92.0	5.0	1.15	1.0
	Sub 4	Pan-0.84	0.088			2.4	86.5	11.1	1.11	1.01
	"H"	Pan-0.84	0.088			1.9	87.5	10.6	1.10	1.00
	Average		0.09							

TABLE C-1 CHARACTERISTICS OF SAMPLES (cont'd.)
REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
8	Mean Tide	0.074-12.70	0.250	16.0	8.4	13.0	62.6		3.55	4.56
	M. L. W.	0.074-2.00	0.170			7.9	92.1		1.27	0.94
	6 Ft.	Pan - 2.00	0.092			0.6	90.6	8.8	1.16	1.06
	12 Ft.	Pan - 0.210	0.088				90.2	9.8	1.09	0.98
	End	Pan - 0.42	0.092				94.0	6.0	1.14	1.09
	"E"	Pan - 0.84	0.090			0.6	93.0	6.4	1.11	1.00
	Sub 3	Pan - 0.84	0.092			1.2	92.9	5.9	1.15	1.08
	"F"	Pan - 2.00	0.092			1.9	91.1	7.0	1.15	1.08
	Average		0.12							
9	"C"	Pan - 0.210	0.090				93.1	6.9	1.10	0.99
	Sub 2	Pan - 0.42	0.096				96.6	3.4	1.14	1.01
	"D"	Pan - 0.42	0.096				95.4	4.6	1.14	1.01
	Average		0.09							

TABLE C-1 CHARACTERISTICS OF SAMPLES (cont'd.)

REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
10	"A"	Pan - 0.210	0.087				91.7	8.3	1.07	0.98
	Sub 1	Pan - 0.42	0.085				95.9	4.1	1.05	1.00
	"B"	Pan - 0.42	0.094				93.0	7.0	1.14	1.05
	Average		0.089							
14	Berm	0.074-0.42	0.20				100.0		1.29	0.94
	Mean Tide	0.074-4.76	0.25		9.9	26.3	63.8		2.93	2.69
	MLW	Pan - 2.00	0.15			0.8	98.4	0.8	1.24	0.83
	6.0	Pan - 0.210	0.088				91.4	8.6	1.10	0.99
	Average		0.17							

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
	Profile No. 1													
Berm												43.2	100.0	100.0
Mean Tide							8.3	20.8	33.3	35.7	39.4	6.7	100.0	100.0
M. L. W.								1.0	1.7	3.0	8.4	29.3	93.9	100.0
6 Ft.										1.4	2.8	25.3	99.0	100.0
12 Ft.								1.0	2.7	5.8	10.0	61.6	98.3	100.0
18 Ft.										0.6	1.8	4.1	89.4	100.0
End											1.6	3.5	90.7	100.0
Totals							8.3	22.8	37.7	46.5	64.0	223.7	671.3	700.0
Ave. Cum.							1.2	3.3	5.4	6.6	9.1	32.0	95.9	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
							Profile No. 1B							
Mean Tide							6.2	9.1	12.5	15.4	28.0	57.5	100.0	100.0
MLW										1.7	17.7	38.0	98.3	100.0
6 Ft.										1.1	2.2	28.4	98.9	100.0
12 Ft.								1.0	2.7	5.4	9.2	58.3	98.6	100.0
End											1.6	3.5	89.0	100.0
Totals							6.2	10.1	15.2	23.6	58.7	185.7	484.8	500.0
Ave. Cum.							1.2	2.0	3.0	4.7	11.7	37.1	97.0	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
Profile No. 2A														
Mean Tide										1.6	10.8	45.0	100.0	100.0
MLW											3.9	17.0	100.0	100.0
6 Ft.										1.9	4.3	10.1	95.1	100.0
12 Ft.											2.4	6.9	88.0	100.0
End											2.2	5.0	88.3	100.0
Totals										3.5	23.6	84.0	471.4	500.0
Ave. Cum.										0.7	4.7	16.8	94.3	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
	Profile No. 3													
Berm										0.8	7.1	58.0	100.0	100.0
Mean Tide										6.7	35.7	66.8	100.0	100.0
MLW											3.5	16.7	99.5	100.0
6 Ft.										1.4	3.5	7.3	97.0	100.0
12 Ft.										0.4	1.6	4.1	83.8	100.0
15 Ft.											1.5	3.3	90.5	100.0
Totals										9.3	52.9	156.2	570.8	600.0
Ave. Cum.										1.6	8.8	26.0	95.1	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
	Profile No. 4													
Berm							3.1	5.0	9.3	16.5	55.8	89.9	100.0	100.0
Mean Tide							5.0	7.6	10.2	12.4	31.1	70.4	100.0	100.0
MLW								9.1	13.6	16.3	33.9	62.0	100.0	100.0
6 Ft.								0.4	0.8	1.2	2.8	5.3	90.8	100.0
12 Ft.										0.6	1.8	4.7	95.2	100.0
End											1.8	30.9	99.0	100.0
Totals							8.1	22.1	33.9	47.0	127.2	263.2	585.0	600.0
Ave. Cum.							1.4	3.7	5.7	7.8	21.2	43.9	97.5	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
Profile No. 7														
"G"								0.8	1.9	3.0	5.7	8.2	95.0	100.0
Sub 4									0.9	2.4	5.4	7.8	88.9	100.0
"H"									0.6	1.9	4.5	6.7	89.4	100.0
Totals								0.8	3.4	7.3	15.6	22.7	273.3	300.0
Ave. Cum.								0.3	1.1	2.4	5.2	7.6	91.1	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
							Profile No. 8							
Mean Tide					4.0	8.3	16.0	24.4	31.0	37.4	54.9	74.6	100.0	100.0
MLW								1.2	3.6	7.9	23.4	62.1	100.0	100.0
6 Ft.								0.2	0.6	0.9	2.7	4.8	91.2	100.0
12 Ft.											1.8	3.6	90.2	100.0
End										0.4	1.3	2.8	94.0	100.0
"E"									0.6	1.2	4.1	6.7	93.6	100.0
Sub 3									0.4	1.2	4.3	7.0	94.1	100.0
"F"								0.4	0.8	1.9	5.1	7.6	93.0	100.0
Totals					4.0	8.3	16.0	26.2	37.0	50.9	97.6	169.2	756.1	800.0
Ave. Cum.					0.5	1.0	2.0	3.3	4.6	6.4	12.2	21.2	94.5	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
									Profile No. 9					
"C"											2.4	4.5	93.1	100.0
Sub 2										1.0	2.7	5.8	96.6	100.0
"D"										1.0	3.3	6.3	95.4	100.0
Totals										2.0	8.4	16.6	285.1	300.0
Ave. Cum.										0.7	2.8	5.5	95.0	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
CUMULATIVE WEIGHT PERCENTAGE RETAINED														
Profile No. 10														
"A"											1.9	3.8	91.7	100.0
Sub 1										0.7	2.5	4.7	95.9	100.0
"B"										0.9	2.6	5.7	93.0	100.0
Totals										1.6	7.0	14.2	280.6	300.0
Ave. Cum.										0.5	2.3	4.7	93.5	100.0

TABLE C-2 SIEVE ANALYSIS - REVERE BEACH

U. S. Standard Sieve No.	2"	1-1/2"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
Profile No. 14														
Berm										3.2	40.9	77.7	100.0	100.0
Mean Tide							9.9	19.8	28.7	36.2	56.2	75.6	100.0	100.0
MLW								0.4	0.8	2.5	7.9	45.1	99.2	100.0
6 Ft.											1.6	4.5	91.4	100.0
Totals							9.9	20.2	29.5	41.9	106.6	202.9	390.6	400.0
Ave. Cum.							2.5	5.1	7.4	10.5	26.7	50.7	97.7	100.0

TABLE C-3 CHARACTERISTICS OF SAMPLES

NANTASKET BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
5	Sea Wall	Pan-38.1	14.00	53.8	10.3	11.5	24.3	0.1	7.88	0.90
	Mid Tide	0.074-19.1	0.33	6.4	8.9	9.3	75.4		1.28	0.94
	MLW	0.074-12.7	0.30	0.5	12.5	12.3	74.7		1.43	1.10
	6 Ft.	0.074-2.0	0.21			1.9	98.1		1.18	1.02
	12 Ft.	Pan-9.52	0.20	0.5	0.9	1.3	96.9	0.4	1.25	1.00
	18 Ft.	Pan-2.0	0.21			3.9	95.6	0.5	1.21	0.96
	24 Ft.	9.52-25.4	27.00	100.0					1.28	0.91
	30 Ft.	12.7-25.4	35.00	100.0					1.14	0.96
	Average		9.66							

TABLE C-1 CHARACTERISTICS OF SAMPLES

NANTASKET BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
12	Sea Wall	9.52-38.1	29.00	100.0					1.22	1.10
	Mid Tide	0.074-2.00	0.30			6.3	93.7		1.15	0.85
	MLW	0.074-2.00	0.37			21.9	78.1		1.22	0.86
	6 Ft.	Pan-2.00	0.24			7.7	92.2	0.1	1.28	0.83
	12 Ft.	Pan-2.00	0.19			4.6	95.1	0.3	1.26	1.00
	18 Ft.	Pan-19.10	0.25	10.5	4.7	24.8	58.9	1.1	3.16	4.10
	24 Ft.	Pan-2.00	0.16			6.6	91.3	2.1	1.33	1.17
	30 Ft.	0.074-38.1	34.00	88.5	1.5	0.9	9.1		1.53	0.74
	Average		8.06							

TABLE C-1 CHARACTERISTICS OF SAMPLES (cont'd.)
REVERE BEACH

Profile No.	Location On Profile	Grain Size (MM) Range	Median Diameter	Character of Material % Gravel	Coarse Sand	Med. Sand	Fine Sand	Silt or Clay	So	Sk
16	Berm	4.76-38.1	19.10	100.0					1.11	0.98
	Mid Tide	0.074-2.00	0.27			5.7	94.3		1.30	0.93
	MLW	0.074-2.00	0.25			13.3	86.7		1.30	1.09
	6 Ft.	0.074-2.00	0.24			6.9	93.1		1.29	0.94
	12 Ft.	Pan-2.00	0.20			6.0	94.0		1.36	0.91
	18 Ft.	Pan-2.00	0.20			4.1	95.0	0.9	1.25	1.00
	24 Ft.	Pan-2.00	0.17			4.0	94.5	1.5	1.29	0.83
	30 Ft.	0.074-5.08	46.00	95.1	1.5	2.2	1.2		1.29	0.80
	Average		8.30							

TABLE C-4 SIEVE ANALYSIS - NANTASKET BEACH

U. S. Standard Sieve	2"	1½"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
	Profile No. 5													
Sea wall		14.1	29.9	44.2	47.9	53.8	59.9	64.1	69.2	75.6	95.3	98.4	99.9	100.0
Mid Tide				3.6	5.5	6.4	11.5	15.3	18.4	24.6	82.2	94.7	100.0	100.0
MLW					0.5	0.5	5.0	13.0	20.9	25.3	77.2	92.6	100.0	100.0
6 Ft.								0.1	0.6	1.9	45.4	85.4	100.0	100.0
12 Ft.						0.5	1.4	1.8	2.7	4.3	43.6	79.5	99.6	100.0
18 Ft.								0.6	1.7	3.9	41.5	80.0	99.5	100.0
24 Ft.			61.5	78.4	95.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
30 Ft.			93.6	93.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Totals		14.1	185.0	219.8	249.7	261.2	277.8	294.9	313.5	335.6	585.2	730.6	799.0	800.0
Ave. Cum.		1.8	23.1	27.5	31.2	32.7	34.7	36.9	39.2	42.0	73.2	91.3	99.9	100.0

TABLE C-4 SIEVE ANALYSIS - NANTASKET BEACH

U. S. Standard Sieve	2"	1½"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
	Profile No. 12													
Sea Wall		24.4	77.1	92.9	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mid Tide								1.6	3.0	6.3	81.9	94.7	100.0	100.0
MLW								5.1	10.0	21.9	88.5	96.3	100.0	100.0
6 Ft.								3.1	5.2	7.7	58.2	83.4	99.9	100.0
12 Ft.								2.1	3.1	4.6	35.4	72.3	99.7	100.0
18 Ft.				1.6	7.5	10.5	15.2	22.0	31.1	40.0	52.4	78.4	98.9	100.0
24 Ft.								1.3	2.9	6.6	24.9	61.3	97.9	100.0
30 Ft.		44.4	72.9	72.9	87.3	88.5	89.7	90.0	90.6	90.9	93.8	97.3	100.0	100.0
Totals		68.8	150.0	167.4	194.2	199.0	204.9	225.2	245.9	278.0	535.1	683.7	796.4	800.0
Ave. Cum.		8.6	18.8	20.9	24.3	24.9	25.6	28.2	30.7	34.8	66.9	85.5	99.6	100.0

TABLE C-4 SIEVE ANALYSIS - NANTASKET BEACH

U. S. Standard Sieve	2"	1½"	1"	3/4"	1/2"	3/8"	4	10	20	40	70	100	200	Pan
LOCATION	CUMULATIVE WEIGHT PERCENTAGE RETAINED													
							Profile No. 16							
Berm		16.2	16.2	46.3	89.8	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mid Tide								0.6	1.6	5.7	70.5	91.1	100.0	100.0
MLW								2.9	6.2	13.3	68.0	90.2	100.0	100.0
6 Ft.								2.0	3.9	6.9	62.0	87.2	100.0	100.0
2 Ft.								2.5	3.9	6.0	44.8	70.8	99.3	100.0
18 Ft.								0.7	1.9	4.1	42.0	76.2	99.1	100.0
24 Ft.								1.6	2.5	4.0	19.5	59.0	98.5	100.0
30 Ft.	31.3	65.9	81.9	88.5	94.2	95.1	96.6	97.7	98.5	98.8	99.1	99.2	100.0	100.0
Totals	31.3	82.1	98.1	134.8	184.0	194.8	196.6	208.0	218.5	238.8	505.9	673.7	796.9	800.0
Ave. Cum.	3.9	10.3	12.3	16.9	23.0	24.4	24.6	26.0	27.3	29.9	63.2	84.2	99.6	100.0

APPENDIX D

PREVAILING WINDS AND STORMS

1. Prevailing Winds. United States Weather Bureau wind records for Boston, Massachusetts, the nearest weather station, located approximately 5 miles southwest of Revere Beach and 12 miles northwest of Nantasket Beach, show that prevailing winds approach the study areas from westerly directions. A wind diagram based on hourly observations of wind speeds and directions for the ten-year period from October 1949 through September 1959, inclusive, is shown on Plate No. 1. It indicates a high preponderance of westerly winds with the greatest duration from the southwest direction and little difference in duration between the northeast and southeast quadrants. Revere Beach faces open water from the southeast quadrant while all winds from the north, northeast, east and southeast quadrants act upon Nantasket Beach with full intensity.

2. Storm Winds. A summary of the number of storms compiled from records of the United States Weather Bureau at Boston, Massachusetts covering the 75-year period 1870-1945, inclusive, is given in the following table:

Storms (1870-1945, inclusive)

Direction	N	NE	E	SE	S	SW	W	NW	Total
No. of storms	3	80	9	14	12	15	13	14	160
Percent of total	2	50	6	9	7	9	8	9	100

The above storms represent major disturbances accompanied by high wind speeds of long duration. Classification of direction of each storm was made in accordance with the predominant direction of wind. Variations in direction during storms are not accounted for.

3. A tabulation showing the duration of winds, their direction and speeds compiled from United States Weather Bureau records at Boston for the period October 1949 to September 1959 is included in Table D-2.

TABLE D-2

WIND SPEEDS AND DIRECTIONS (OCTOBER 1949 - SEPTEMBER 1959 INCLUSIVE)

BOSTON, MASSACHUSETTS

NUMBER OF HOURS

Wind Speed (M. P. H.) / Direction	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & Over	Total	% Total Duration	Average Speed M. P. H.	Wind Movement Miles	% Total Movement	% Duration per Degree
N	124	703	1,681	1,344	380	125	15	3	-	4,375	5.0	12.2	53,481	4.6	0.22
NNE	92	438	985	832	382	166	31	5	1	2,932	3.3	13.4	39,356	3.4	0.15
NE	117	553	1,068	1,056	533	235	87	32	11	3,692	4.2	14.4	53,268	4.6	0.19
ENE	120	512	908	1,027	459	219	55	16	4	3,320	3.8	14.1	46,825	4.0	0.17
E	137	537	1,376	1,321	383	140	50	22	2	3,968	4.5	13.0	51,756	4.5	0.20
ESE	136	631	1,616	1,396	268	68	14	-	4	4,133	4.7	11.6	48,134	4.2	0.21
SE	124	636	1,370	974	135	26	-	-	1	3,266	3.7	11.0	35,797	3.1	0.16
SSE	98	618	1,150	508	93	27	3	2	1	2,500	2.9	10.3	25,646	2.2	0.13
S	128	912	1,591	958	251	62	13	3	-	3,918	4.5	11.0	42,967	3.7	0.20
SSW	122	905	2,081	1,911	691	217	48	16	3	5,994	6.8	13.1	78,554	6.8	0.30
SW	118	1,061	4,098	4,357	1,188	278	35	4	-	11,139	12.7	13.2	147,485	12.8	0.56
WSW	96	686	2,259	2,329	557	103	17	1	-	6,048	6.9	12.7	76,984	6.7	0.31
W	89	695	2,162	2,361	891	274	69	6	-	6,547	7.5	14.0	91,469	7.9	0.33
WNW	93	929	3,017	3,406	1,491	564	71	11	-	9,582	10.9	14.5	138,485	12.0	0.48
NW	102	845	2,587	3,479	1,558	635	109	7	4	9,326	10.7	15.0	140,066	12.1	0.48
NNW	94	633	2,011	2,418	902	203	23	4	-	6,286	7.2	13.7	86,274	7.4	0.32
Calms										606	0.7				
Totals	1,790	11,294	29,960	29,677	10,162	3,342	640	132	31	87,632	100.0	13.0	1,156,547	100.0	

APPENDIX E

TIDES

1. General. Tides in the study area are semi-diurnal. The mean ranges are 9.0 and 9.4 feet in Revere Beach and Nantasket Beach, respectively. It is considered that the records from the tide station at Boston also apply to the study areas. Unless otherwise stated, the elevations given herein are referred to the plane of mean low water.

2. Frequency of Higher Tides. The frequency of occurrences of tides which exceeded the mean range by 2.0 feet or more, based on 30-1/3 years of observations at Boston, Massachusetts are shown in the following tabulation:

Feet Above MHW	Number of Occurrences*	Avg. Number of Occurrences per year*
4.3	1	0.03
4.2	2	0.06
4.1	2	0.06
4.0	2	0.06
3.9	2	0.06
3.8	2	0.06
3.7	3	0.1
3.6	4	0.1
3.5	5	0.2
3.4	7	0.2
3.3	14	0.5
3.2	21	0.7
3.1	32	1.1
3.0	44	1.5
2.9	67	2.2
2.8	83	2.7
2.7	110	3.6
2.6	144	4.8
2.5	205	6.8
2.4	277	9.1
2.3	358	11.8
2.2	463	15.3
2.1	560	18.5
2.0	741	24.5

*Equaling or exceeding the stated elevation.

3. Extraordinary Storm Tides. Storms with exceptionally high flood levels have been reported for this area. On 29 December 1959 a damaging northeast storm off the New England coast caused tidal flooding of 14.2 feet above mean low water (4.7 feet above MHW) at Boston. In January 1961, another damaging storm occurred with a flood level reported for Boston of 14.2 feet above mean low water (4.7 feet above mean high water). On 25 May 1967 a storm occurred causing some erosion and flood damage with a flood level of 13.5 feet above mean low water experienced at Boston. Because of the damaging nature of the 1959 storm, a resumé report was completed by the U. S. Army Engineer Division, New England Corps of Engineers in 1960. In this report, information on other exceptional storms was described. One very serious storm noted occurred on 24 February 1722 with a flood level at Boston reported at 15.4 feet above mean low water (5.9 feet above mean high water). Dates of other storms as discussed in the resumé report with tide heights in feet above mean low water at Boston are:

April 16, 1951, Lighthouse Storms	14.9 ft.	(5.4 ft. above MHW)
November 27, 1898, Portland Gale	14.4 ft.	(4.9 ft. above MHW)
December 26, 1909, Christmas Gale	14.9 ft.	(5.4 ft. above MHW)
April 22, 1940	13.8 ft.	(4.3 ft. above MHW)

4. Design Storm Tide Level. The tidal level selected for design of the protective measures is 3.0 feet above mean high water, which is the level occurring during an ordinary northeast storm with a frequency of about once a year.

APPENDIX F

SHORELINE AND OFFSHORE DEPTH CHANGES

1. General. Shoreline changes were determined from comparative positions of the high water shoreline located by the United States Coast and Geodetic Survey in 1849, 1893-94, 1919 and 1944 and by the Corps of Engineers in 1945-46 and 1962 for Revere Beach. Nantasket Beach's shorelines were located by the U. S. C. & G. S. in 1847, 1893 and 1944 and by the Corps of Engineers in 1946 and 1963. The 1944 survey was made by aerial photographic methods and its position should not be used to determine the degree of change.

2. Analysis of Revere Beach shoreline positions as shown on Plate 12 for these years reveal that accretion has occurred along the Saugus River since 1919 with the mean high water line moving toward the river. The northerly half of the beach at Point of Pines has experienced both erosion and accretion. Since 1919 the mean high water line has moved seaward approximately 250 feet.

3. The southerly half of the Point of Pines beach has undergone periods of recession and accretion. The net change of the mean high water position is minor.

4. From Profile 2 southward there has been accretion and recession at the mean high water line. The latest position is one of recession for a lateral distance of about 2, 000 feet. From this point the latest position of the mean high water line shows accretion varying up to 100 feet since 1893.

5. Starting at a point approximately 700 feet north of Profile 4, the latest development, that which occurred between 1945 and 1962, was one of recession amounting up to about 70 feet. At Profile 12, the latest mean high water line changes from recession to accretion and remains thus for the remainder of the study area.

6. The mean low water line showed a continuous seaward movement between 1893 and 1945 for the entire shorefront between Point of Pines and Roughans Point. Prior to 1893 there was recession

from the Point of Pines to a point approximately 800 feet north of Profile 3. Since 1847 there has been a continuous seaward movement of up to 1200 feet from this point to a point 300 feet north of Profile 4. From Profile 6 recession was shown between the years 1847 and 1893 except for a small pocket at Roughans Point.

7. The Point of Pines beach shows a seaward movement of the mean low water line after 1893 which ranged up to 1, 000 feet since 1945. In 1945 an offshore bar was formed in the area of Profile 2 which consolidated into a continuous mean low water line by 1962.

8. At the point 300 feet north of Profile 4 to Profile 8, there has been recession between 1945 and 1962 ranging up to 180 feet in its center. From this point, the latest mean low water line follows fairly close to that of 1945 to a point midway between Profiles 10 and 12 and is then seaward for the remaining distance of the study area.

9. The 6, 12, and 18-foot offshore depth contours were developed in the area by the United States Coast and Geodetic Survey from surveys made in the years 1846-48, 1853-54, 1892, 1895 and 1945. Contours were also developed from profiles surveyed by the Corps of Engineers in 1962. The shallow nature of the offshore areas did not allow for the 12 and 18-foot contours to be shown in their entirety.

10. The 6-foot depth contour fronting the Point of Pines Beach indicates a constant realignment of the channel to Saugus River. At Profile 2 the contour moved landward a distance of 2, 000 feet between 1846 and 1853, returned to its original position in 1892, and then moved landward again, this time 1, 300 feet, in 1962.

11. At a point 400 feet north of Profile 3 there was no change in the 6-foot depth contour between 1846 and 1892. There was a landward movement of 200 feet between this date and 1962. Between Profiles 3 and 4 there was a general seaward movement which ranged up to 1200 feet between 1846 and 1962. Between Profile 4 and the Cherry Island Bar breakwater there was general landward movement throughout.

12. The 12-foot depth contour has varied between landward and seaward movements throughout the period of record. The net result is one of landward movement of 500 feet betwen 1846 and 1962 at Profile 2 and a seaward movement ranging up to 500 feet starting midway between Profiles 2 and 3 and continuing to Profile 8 between the same dates.

13. The information pertaining to the 18-foot depth contour is of such a limited nature that no comparison could be made.

14. Analysis of Nantasket Beach shoreline positions as shown on Plate 16 for the years noted discloses that movements of the mean high water line varied between accretion and recession throughout the period of record. There was erosion between 1847 and 1893 resulting in a horizontal movement landward of the mean high water line from 20 to 60 feet. Between 1893 and 1944 the beach prograded and the mean high water line moved seaward to approximately the position it occupied in 1847. Between 1944 and 1962 the mean high water line once more receded and its latest position was similar to that of 1893.

15. Accretion averaging 50 feet in shoreline movement occurred between Profiles 14 and 8 for the mean low water line and between Profiles 8 and 6 there was a landward movement in the shoreline of 40 feet between the years of 1847 and 1893. The mean low water line remained stable from 1893 to 1946, except for a landward movement varying up to 160 feet between Profiles 12 and 10, and 100 feet between Profiles 6 and 3. Accretion between Profiles 2 and 1 resulted in a seaward movement varying up to 140 feet. The net result of changes at the mean low water line between 1847 and 1946 has been accretion nearly balancing erosion. The 1946 mean low water line is seaward of the 1847 line between Profiles 14 and 12, 10 and 8, and 4 and 1, and is landward between Profiles 12 and 10 and Profiles 8 and 4. However, after 1946 the mean low water line has receded the entire length of the study area ranging up to 130 feet.

16. The changes which have taken place in offshore areas are indicated by the comparative 6, 12 and 18-foot depth curves. These curves are developed from the surveys used for the development of the shorelines discussed previously.

17. The 6-foot depth contour has shown a continuous landward movement during the period of record except for an area between 300 feet south of Profile 12 and 200 feet south of Profile 10 during the period between 1944 and 1946.

18. The 12-foot depth contour has shown varied movements indicating both erosion and accretion during the period of record, but erosion dominated between Profiles 14 and 8 with the 1893 curve being generally from 100 to 140 feet landward of the 1847 curve. Accretion was the result between Profiles 8 and 1. Between 1893 and 1944, the 12-foot depth curve north of Profile 12 moved seaward. South of Profile 12, erosion moved the curve landward for distances varying up to 50 feet. The net effect between 1847 and 1944 was accretion in the northern part of the area and varying amounts of erosion and accretion in the southern part of the area. The 1946 depth curve indicates that since 1847 there has been accretion between Profiles 14 and 12, erosion between Profiles 12 and 6, accretion between Profiles 6 and 2, and erosion in the vicinity of Profile 1. Movements of the depth curves between 1847 and 1946 have varied up to 150 feet but the average movement is about 50 feet. It is to be noted that while erosion has taken place between Profiles 2 and 1 since 1893, the 1944 curve indicates a shoal area forming about 500 feet seaward of the main 12-foot curve. The 1962 curve shows erosion along the entire shoreline.

19. The movements of the 18-foot depth curves do not evidence any continuous process of erosion or accretion in specific areas, but show that the processes reverse themselves at different periods. Between 1847 and 1893 accretion dominated the area between Profiles 14 and 1, with the movement of the curve for 1893 averaging 200 to 300 feet seaward. Between Profiles 2 and 1, the 1893 curve indicates a shoal about 200 feet seaward of the main depth curve. Between 1893 and 1944, the processes of erosion and accretion were reversed in many areas. The 1944 curve shows a number of new shoal areas seaward of the curve. Between Profiles 14 and 1, there was generally erosion with the average landward movement of the depth curve being 100 feet. Between Profiles 2 and 1, however, the depth curve moved seaward to include the small shoal shown by the 1893 depth curve, and another small shoal is shown still further seaward. The 1962 curve follows closely to the 1944 line except in an area 300 feet south of Profile 10 to 300 feet north of Profile 6 where there is erosion and the remaining area to the south where there is accretion.

APPENDIX G

PRIOR AND EXISTING PROTECTIVE STRUCTURES

Available information concerning prior and existing protective structures is listed below. Information is listed to correspond with the identifying numbers used on Plates 2, 3 and 4.

REVERE BEACH

1. Northern Circle Seawall. The Northern Circle seawall was constructed in 1904 around the seaward perimeter of the highway traffic circle. The wall is a gravity-type, concrete wall with reinforcing steel. The top of the coping is at elevation 21.5 above mean low water, the base of the wall is at elevation 7.0. This seawall has been subjected to recurring damage from wave action. Repairs were required in 1923 and again in 1928 when the wall was jacked back in place and a toe wall added after it had been undermined and was tipping over. Riprap was placed around the base of the wall. The wall is in good condition.

2. Curb Wall. Original construction in the area from Northern Circle southward for a distance of 900 feet consisted of highway curb along the seaward edge of the promenade. The curb was replaced in 1940 and 1941 with a concrete curb wall which acts as a retaining wall for the highway. This wall is 5 feet high, 12 inches wide at top and 18 inches wide at bottom. The wall projected 1 foot above the level of the promenade (now used for a parking area). The wall is in fair condition.

3. Stepped Seawall. The stepped seawall which extends southwesterly from a point 900 feet south of Northern Circle was originally constructed in 1914 and has a length of 1,500 feet. This original wall was damaged and in 1931 was rebuilt. At the time of rebuilding, riprap was placed in front of the wall. Some riprap was placed on either side of the wall. The wall, being constructed at the mean high water line, has been subject to continuous wave action which resulted in the spalling and breaking of the lower concrete steps. A new toe was constructed in 1963 and 1964. The wall is in good condition.

4. Reinforced Concrete Wall. In back of the stepped seawall and running southwesterly to the Oak Island St. Pavilion, a distance of 4, 850 feet, there is a reinforced concrete wall. The 500 feet of wall immediately south of the stepped wall was constructed in 1962 and the remainder in 1963-64. The top elevation of the wall is 3'6" above the level of the parking area. There are three concrete ramps leading to the beach at intervals along the retaining wall, which were originally constructed prior to 1916 and have been rebuilt at various times because of damage. A brick building housing sanitary facilities was constructed on the backshore area about 1, 200 feet north of Oak Island St. in 1937. The wall is in excellent condition.

5. Pavilion at Oak Island Street. The pavilion at the foot of Oak Island Street was constructed in 1904. It is 549 feet long and serves as a shelter. The seaward wall of the pavilion was constructed as a concrete gravity type seawall with a top width of 2 feet and a bottom width of 7-1/2 feet. The top of the wall is at elevation 23 feet above mean low water and the base at elevation 8 feet above mean low water. The wall is in good condition.

6. Curb Wall. Between Oak Island Street pavilion and Revere Street pavilion, a distance of 1, 300 feet, the beach is bordered by a continuous parking area which was originally a promenade and along which there was originally a standard concrete curb. In 1940 and 1941 the curb was replaced with a concrete curb wall which acts as a retaining wall, as described in paragraph 2 above. There is a concrete ramp leading to the beach at one location along the wall. The wall is in fair condition.

7. Pavilion at Revere Street. The pavilion at the foot of Revere Street was built at the same time as the Oak Island Street pavilion (1904). Both pavilions are of similar type construction. Concrete fronting the pavilion is in poor condition.

8. Concrete Apron. The original construction between the Revere Street and bathhouse pavilions consisted of a stepped seawall similar in detail to the wall described in paragraph 3 above, except that four bastions were provided at intervals along its length. In 1957 the stepped wall was covered with a concrete apron, leaving just the top of the bastions exposed. A reinforced concrete wall built in 1960 fronts the walk. Top elevation of the wall is 21. 5 feet above mean low water. The wall is in good condition.

9. Bathhouse Pavilion. The pavilion at the bathhouse was constructed around 1897. It is constructed of concrete and is similar to the pavilion at Revere Street, except that there were two tunnels passing under the pavilion from the beach to the bathhouse across the highway. A concrete apron, having a stepped surface was constructed in front of the pavilion wall. These steps were damaged and were covered with concrete in 1940 to form a smooth-surfaced ramp. The concrete is in fair to poor condition.

10. Reinforced Concrete Wall. The original construction between the bathhouse pavilion and the pavilion at Shirley Avenue consisted of a concrete curb constructed about 1910 along the edge of the sidewalk. In 1960 a reinforced concrete wall was constructed fronting the sidewalk. Top elevation of the wall is 21.5 feet above mean low water. The wall is in good condition.

11. Shirley Avenue Pavilion. The pavilion at Shirley Avenue was constructed about 1897. It is similar to the Revere Street pavilion except that a bastion was constructed in the central part of the pavilion. In 1964 the face of the pavilion was reconstructed and a cap was added. It is in good condition.

12. Eliot Circle Seawall. The Eliot Circle seawall is a gravity-type concrete wall constructed in 1910. The seawall has a top elevation of 18.2 feet above mean low water. Concrete is in fair to poor condition and needs repair.

NANTASKET BEACH

1. The northern end of the study area from the MDC Reservation limit at Phipps Street to a riprap revetment contains a first aid and comfort station constructed in 1959. A reinforced concrete wall fronts the building and is constructed to elevation 20.3 feet above mean low water. This wall is in good condition.

2. Riprap Revetment. From a point approximately 500 feet north of a reinforced concrete wall, and running south to the wall, there is heavy riprap constructed in 1949 to an elevation of 18.2 feet above mean low water. The riprap is in good condition.

3. Concrete Wall. Starting at the southern end of the riprap and running to the south for the remaining shorefront, there is a concrete wall. The original wall was constructed and reconstructed

at various intervals. The original construction for that portion of the wall reaching to the ramp near Profile 10 consisted of unreinforced concrete with a curved face. The top elevation of the wall was 19.6 feet above mean low water. Access to the beach is provided at various locations by steps. The section of the wall between the ramp near Profile 10 and the first set of stairs to the north was constructed about 1926. Between 1927 and 1936, the wall was extended to the largest bastion. The bastion was built in 1936. The wall was extended to the next bastion in 1937 and to its end in 1938. The section of wall between the northernmost two bastions, a distance of about 175 feet, was reconstructed in 1941. The new wall is of reinforced concrete. In 1944, the extreme northwesterly end of the wall was rebuilt for a distance of approximately 160 feet including a part of the most northerly bastion. In 1965, a concrete cap wall was constructed on the northernmost 125 feet of the wall at a top elevation of 22.4 feet above mean low water. The wall between Profiles 10 and 12 is in need of repair; from Profile 12 to the northern end it is in good condition.

4. Concrete Wall. The concrete seawall fronting the bathhouse area, starting at the ramp near Profile 10 and running to the south for a distance of approximately 550 feet, was constructed in 1916 when the area was used for amusement rides. The circular section of the wall was introduced in front of an existing merry-go-round. The amusement rides have been removed and replaced by the present State-operated bathhouse. The top elevation of the wall is 19.6 feet above mean low water. The wall is in good condition.

5. Concrete Wall. The concrete wall fronting the concert hall area starts at a point at the south end of the bathhouse area and continues to the south for a distance of approximately 600 feet. This was constructed in 1927. The top of the wall was approximately 19.5 feet above mean low water. The concrete steps leading to the beach were constructed in 1928. Portions of this wall were reconstructed in contracts dating back to 1956. The elevations of the new sections of wall are 22.4 feet and 19.4 feet above mean low water. The wall is in good condition.

6. Concrete Wall. The section of the concrete wall running from the south edge of the concert hall area and continuing southward, a distance of approximately 250 feet, was constructed in 1920 as a concrete bulkhead under the no longer existing Nantasket Hotel. The top elevation of the wall is approximately 19.5 feet above mean low water. The wall is in good condition.

7. Concrete Wall. The remaining sections of concrete wall from the former hotel bulkhead to the south limit of the M. D. C. reservation were constructed as follows:

a. Northern 1400 feet - Constructed in 1915. Elevation varies from 21. 6 feet above mean low water to 18. 2 feet above mean low water. A portion of this wall was reconstructed in 1961 to an elevation of 19. 2 feet above mean low water.

b. Southern 225 feet - Constructed in 1927. Elevation of the top of wall is 18. 2 feet above mean low water.

This wall is in good condition.

APPENDIX H

BEACH PROFILES

1. General. 16 beach profiles were surveyed during 1962 at selected locations in Revere Beach and 9 beach profiles were surveyed at Nantasket Beach as shown on Plates 2 and 4. They varied from 1, 700 feet to 6, 200 feet in length and extended from the beach crest seaward to depths up to 22 feet below mean low water at Revere Beach. At Nantasket Beach, the profiles varied in length from 1, 000 feet to 4, 100 feet and extended from the beach crest seaward to depths up to 30 feet below mean low water. Plots of the profiles are shown on Plates 5 to 9. Beach slopes were measured from the plotted profiles and they are shown in the following table. Slopes are given from the landward to the seaward ends of the profiles, thus: 1/25 above -10. 0, meaning one vertical over 25 horizontal above an elevation of 10 feet below mean low water. Slopes flatter than 1/100 are listed as level.

BEACH PROFILES

No.	Location	Slopes
1	Revere Beach	1/67 (14 to 11); 1/35 (11 to 7); level (7 to 1); 1/11 (1 to -16); 1/34 (-16 to -13); 1/65 (-13 to -7) level (-7 to 1); 1/5 (1 to -19)
1-A	Revere Beach	1/11 (17 to 3); level (3 to -1); 1/40 (-1 to 10); 1/70 (-10 to 2); level (-2 to -7); 1/9 (-7 to -22)
1-B	Revere Beach	1/4 (18 to 9); 1/20 (9 to 4); level (4 to -5); 1/55 (-5 to -9); level (-9); 1/50 (-9 to -3); level (-3 to -10)
2	Revere Beach	1/13 (15 to 4); level (4 to -13)
2-A	Revere Beach	1/4 (17 to 7); 1/24 (7 to 2) level (2 to -13)

No.	Location	Slopes
2-B	Revere Beach	1/18 (15 to 7); 1/43 (7 to 1) level (1 to -12)
3	Revere Beach	1/25 (12 to 8); 1/54 (8 to 1) level (1 to -13)
3-A	Revere Beach	1/17 (16 to 9); 1/63 (9 to 2) level (2 to -11)
3-B	Revere Beach	1/10 (19 to 8); 1/63 (8 to 2) level (2 to -12)
4	Revere Beach	1/13 (12 to 6); level (6) 1/28 (6 to 1); level (1 to -12)
6	Revere Beach	1/3 (19 to 13); 1/6 (13 to 6); 1/37 (6 to MLW); level (MLW); 1/60 (MLW to -3); level (-3 to -12)
8	Revere Beach	1/9 (15 to 6); 1/57 (6 to -1); level (-1 to -12)
10	Revere Beach	1/8 (19 to 11); 1/25 (11 to MLW) level (MLW to -13)
12	Revere Beach	1/11 (18 to 9); 1/40 (9 to 5); 1/20 (5 to 1); level (1 to -11)
14	Revere Beach	1/27 (19 to 16); 1/4 (16 to 11) 1/80 (11 to 12); 1/33 (12 to 1) level (1 to -7)
16	Revere Beach	1/13 (13 to 7); 1/90 (7 to 3); level (3 to -3)
4	Nantasket Beach	1/60 (20 to 19); 1/8 (19 to 9); 1/43 (9 to -4); level (-4 to -6)
5	Nantasket Beach	1/7 (11 to 8); 1/48 (8 to -5); level (-5 to -7); 1/71 (-7 to -14); 1/30 (-14 to -16); 1/13 (-16 to -7); 1/7 (-7 to -13); level (-13); 1/80 (-13 to -17); level (-17) 1/67 (-17 to -20); level (-20); 1/20 (-20 to -23); level (-23 to -24); 1/67 (-24 to -30); level (-30)

No.	Location	Slopes
6	Nantasket Beach	1/10 (12 to 8); 1/48 (8 to -2) 1/96 (-2 to -11); level (-11 to -16) 1/91 (-16 to -30)
8	Nantasket Beach	1/12 (12 to 7); 1/51 (7 to MLW) 1/83 (MLW to -15); level (-15 to -23) 1/40 (-23 to -30)
10	Nantasket Beach	1/9 (18 to 7); 1/53 (7 to -4); level (-4 to -26); 1/55 (-26 to -30)
12	Nantasket Beach	1/6 (17 to 7); 1/51 (7 to -3); 1/93 (-3 to -25); 1/35 (-25 to -29) level (-29 to -30)
14	Nantasket Beach	1/3 (15 to 8); 1/52 (8 to -5); 1/87 (-5 to -24); 1/57 (-24 to 30)
15	Nantasket Beach	1/17 (12 to 6); 1/60 (6 to -1) 1/74 (-1 to -30)
16	Nantasket Beach	1/17 (13 to 7); 1/58 (7 to -1) 1/74 (-1 to -30)

2. A comparison was made between the profiles surveyed in 1962 and prior profiles surveyed in 1946.

3. At Revere Beach, 201, 255 cubic yards of sand was pumped from an offshore borrow area to the southerly 5, 000 feet of beach in 1954. However, MDC before and after surveys indicated only about 90, 000 cubic yards remained on the beach. This, in part, is reflected in the Revere profiles between Profile 4 and Profile 16. Part of the material placed in 1954 still remains on the beach. The most apparent effect is one of steepening of the beach slope between mean high water and mean low water with a leveling off below mean low water.

4. At Nantasket Beach, the change taking place in the beach is one of recession along the entire length. The slopes vary from 1/3 to 1/17 above mean high water. Between mean high water and mean low water, the slopes vary from 1/43 to 1/60. The beach generally tends to level off at a depth ranging from mean low water to 5 feet below mean low water.

APPENDIX I

ESTIMATES OF COST OF IMPROVEMENTS

1. General. A useful life of 50 years has been used in determining amortization charges. An annual interest rate of 3.25 percent has been used for the annual charges. Annual nourishment requirements for beach replenishment have been estimated on the basis of losses of natural beach fill, modified to allow for somewhat greater losses of the artificial fill considered likely to be representative for the area. The preauthorization cost of $40,000 for completion of the study, shared with the Federal Government by the Commonwealth of Massachusetts ($17,000, the Commonwealth's share) is not included in the First Cost of the projects.

2. Revere Beach. The plan of protection and improvement consists of beach widening by direct placement of sandfill and periodic nourishment at suitable intervals of time (Plan 1 - Plates 19 and 20), or, in lieu thereof, (Plan 2 - Plates 17 and 18), consideration of construction of 8 groins and beach widening. It is conservatively estimated that groin construction might, logically, only reduce nourishment requirements by 50 percent. Assuming that they could be constructed for the sole purpose of maintaining project width and alignment, Federal participation in periodic nourishment with groins is included in accordance with provisions set forth in EM 1120-2-101, paragraph 1-107b.

REVERE BEACH, MASS.

PLAN 1. NO GROINS

First Cost - Federal and Non-Federal

Initial sandfill 830,000 c.y. x $2.25		$1,870,000
Contingencies		280,000
	Sub-Total	$2,150,000
Engineering & Design		85,000
	Sub-Total	$2,235,000
Supervision & Administration		165,000
[3] Total First Cost		$2,400,000
Federal Share of Cost (1/2)		$1,200,000
Non-Federal Share of Cost (1/2)		$1,200,000

REVERE BEACH, MASS. (Cont'd)

PLAN 1. NO GROINS (Cont'd)

Annual Charges

Federal Investment

Interest 0.0325 (0.05625) x $1,200,000	$ 39,000
Amortization 0.00823 (0.03898) x $1,200,000	9,900
(1) & (2) Periodic Beach Nourishment 10,000 c.y. @ $2.50	25,000
Total Federal Annual Charges	$ 73,900

Non-Federal Investment

Interest 0.0325 x $1,200,000	$ 39,000
Amortization 0.00823 x $1,200,000	9,900
(1) & (2) Periodic Beach Nourishment 10,000 c.y. @ $2.50	25,000
Total Non-Federal Annual Charges	$ 73,900
TOTAL ANNUAL CHARGES	$ 147,800

(1) About five times erosion of natural beach 1900-1946

(2) Federal participation in periodic nourishment to be for an initial period of 10 years, after which time benefits and techniques would be reevaluated.

(3) Exclusive of $20,000 preauthorization cost.

PLAN 2. WITH GROINS

First Cost - Federal and Non-Federal

Sandfill 830,000 c.y. x $2.25	$1,870,000
Groins 49,000 T x $13.00	630,000
Sub-Total	$2,500,000

REVERE BEACH, MASS. (Cont'd)

PLAN 2. WITH GROINS (Cont'd)

Brought Forward		$2,500,000
Contingencies		375,000
	Sub-total	$2,875,000
Engineering and Design		125,000
	Sub-total	$3,000,000
Supervision & Administration		250,000
Total First Cost		$3,250,000
Federal Share of Cost (1/2)		$1,625,000
Non-Federal Share of Cost (1/2)		$1,625,000

Annual Charges

Federal Investment

Interest 0.0325 x $1,625,000	$ 52,800
Amortization 0.00823 x $1,625,000	13,400
Periodic Beach Nourishment 5,000 c.y. @$2.50	12,500
Total Federal Annual Charges	$ 78,700

Non-Federal Investment

Interest 0.0325 x $1,625,000	$ 52,800
Amortization 0.00823 x $1,625,000	13,400
Maintenance Groins 500 Tons Stone @ $13.00	6,500
Periodic Beach Nourishment 5,000 c.y. @ $2.50	12,500
Total Non-Federal Annual Charges	$ 85,200
TOTAL ANNUAL CHARGES	$ 163,900

3. Nantasket Beach. The plan of protection and improvement consists of beach widening by direct placement of sandfill, and periodic nourishment at suitable intervals of time.

NANTASKET BEACH, MASS.

First Cost - Federal and Non-Federal

Sandfill 682,400 c. y. @ $2.25		$1,535,000
Contingencies		230,000
	Sub-total	$1,765,000
Engineering & Design		85,000
	Sub-total	$1,850,000
Supervision & Administration		150,000
(1) Total First Cost		$2,000,000
Federal share of cost (1/2)		$1,000,000
Non-Federal share of cost (1/2)		$1,000,000

(1) Exclusive of preauthorization costs of $20,000.

Annual Charges

Federal Investment

Interest 0.0325 x $1,000,000	$ 32,500
Amortization 0.00823 x $1,000,000	8,200
(1) & (2) Periodic beach nourishment 10,000 c. y. @ $2.50	25,000
Total Federal Annual Charges	$ 65,700

Non-Federal Investment

Interest 0.0325 x $1,000,000	$ 32,500
Amortization 0.00823 x $1,000,000	8,200
(1) & (2) Periodic beach nourishment 10,000 c. y. @ $2.50	25,000
Total Non-Federal Annual Charges	$ 65,700
TOTAL ANNUAL CHARGES	$ 131,400

(1) Triple the rate of erosion of natural beach 1945-1963.

(2) Federal participation in periodic nourishment to be for an initial period of 10 years, after which time benefits and techniques would be reevaluated.

APPENDIX J

ESTIMATES OF BENEFITS FROM IMPROVEMENTS

1. General. The benefits computed herein are based on the promotion and encouragement of healthful recreation of the people by protection and improvement of public beaches and prevention of direct damages to public property. The intangible benefit of increasing the desirability of the beach and, therefore, increasing pleasure obtained therefrom is not evaluated. All benefits evaluated are non-Federal public benefits. The methods used for computing benefits are described below.

2. Direct Damages Prevented. The proposed improvements will reduce maintenance costs of existing protective structures and prevent losses of some structures. Reports from the Metropolitan District Commission on past expenditures indicate that maintenance costs average $65,000 a year for Revere Beach and $33,000 a year for Nantasket Beach. It is considered that with an improvement this figure would be reduced by about $50,000 for Revere Beach and $25,000 for Nantasket Beach.

3. Recreational Benefits. Revere Beach is connected to other parts of the city of Revere and to all sections of Metropolitan Boston by trunk highways. The amusement area of the beach is served directly by the Massachusetts Bay Transportation Authority system, being reached from all parts of Boston. Free public parking areas are provided for automobiles along most sections of the Metropolitan District Commission Reservation. The beach is open to full and free use by the public. A large bathhouse is operated at the beach by the Commission. The location and accessibility of the area, the development of the State-operated reservation and the development of the amusement park have made Revere Beach the most popular and most used beach in Massachusetts.

4. Nantasket Beach is traversed its entire length by paved roads which constitute the southerly end of the State circumferential highway around Metropolitan Boston. It is also connected by an express highway to the main route to Boston. Public transportation is provided by bus system from Quincy, which connects with several transportation systems serving the Metropolitan area. During the summer, there is direct steamboat service between the beach and the center of Boston. Free public parking is available. Public and private bathhouses exist.

5. Nantasket and Revere Beaches, both being a part of Metropolitan Boston with both having full beach facilities, both having additional features such as amusements, restaurants, etc., make the available beach area the limiting factor as to attendance. It is considered that on weekends and holidays the beaches would be filled to the capacity of the proposed available beach area. Weekday attendance is considered to be one-third the peak attendance. The bathing season in New England generally extends from about the middle of June to the middle of September, depending on weather conditions. Allowing for about twenty-five percent inclement weather, it is assumed that there would be 20 peak days when the beaches would receive optimum use and 43 days of average use. The present beach area of Revere Beach is sufficient for future weekday usage and so the benefit would be derived only by the increased usage on peak days. The existing beach at Nantasket is insufficient in area to handle future weekday attendance as well as peak-day attendance. The desirable area for each bather is 75 square feet of dry beach. A reasonable per capita recreational value of a fully developed, publicly-owned beach, with full use facilities and no overcrowding, is $0.75 per visit--assumed to be equivalent to the charge which would be made if the beach were privately controlled and operated. The reported attendance at these beaches would result in some overcrowding on peak days. The recreational benefit would be based on the additional attendance over the limits imposed by the lack of beach area, assuming a daily turnover of two, but not allowing for benefits from overcrowding on peak days.

REVERE BEACH

With Project of 185-foot Dry Beach Width

Dry beach area	2,312,500 square feet
Peak-day Capacity (2,312,500/75)2	62,000 people
Weekday Attendance 62,000/3	21,000 people

Present Dry Beach

Dry beach area	896,000 square feet
Capacity (896,000/75)2	24,000 people

Increased seasonal attendance = 62,000 - 24,000 = 38,000 people x 20 (assumed number of peak days) = 760,000 people.

Recreational benefit for Revere Beach = 760,000 people x $0.75 = $570,000.

NANTASKET BEACH

With Project of 190-foot Dry Beach Width

Dry beach area	1, 266, 300 square feet
Peak-day Capacity (1, 266, 300/75)2	34, 000 people
Weekday Attendance 34, 000/3	11, 000 people

Present Dry Beach

Dry beach area	365, 500 square feet
Capacity (365, 500/75)2	10, 000 people

Increased seasonal attendance = 34, 000 - 10, 000 = 24, 000 people x 20 (assumed number of peak days) = 480, 000 people plus (11, 000 - 10, 000 = 1, 000 people x 43, assumed number of week days, = 43, 000 people) = 523, 000 people.

Recreational benefit for Nantasket Beach = 523, 000 people x $0. 75 = $392, 250.

6. Both Revere and Nantasket Beaches are located within the intermediate suburban area of Boston where the increase in population of nearby towns during the past ten years has ranged as high as fifty percent. There has also been a steady increase of tourists vacationing within the area. Although there are some small salt water bathing beaches along the north and south shores, most of these are not open to the general public. The increased population trend coupled with a continuing increase in outdoor recreational activities and the scarcity of available beaches within the area easily justify development of both these major beach areas.

7. At presently estimated prices, further widening of the beach berms to accommodate additional bathers would cost about $2 per foot of beach width, per foot of beach length. The break-even point, based on a turnover of two bathers per day, would require about 5 days of beach use annually to justify additional widening. It would appear that additional widening, to maximize net return, could be accomplished initially, up to the point that additional increments of beach width are not justified. Were these complex construction projects, for which initial decisions would foreclose later options, it would certainly be appropriate to consider the desirability of maximizing net return now. However, the projects as formulated do not physically foreclose widening in the future. The beach widths selected were also the minimum required by the structural aspects of beach stability. The difficulty is that the demand for public beach space is so strong that a

larger project could be justified out of proportion to the competitive allocation of public funds to support construction at these locations. The projects selected, then, recognize the existing socio-political constraints while meeting the minimum beach protection structural requirements. Any significant beach widening beyond that recommended would soon come against physical restraints in terms of access, parking, and other facilities which, in turn, would require changes in contiguous land use patterns. This situation is so complex that judgments on further beach widening should not be made without more experience at these locations.

APPENDIX K

DESIGN ANALYSIS

1. Design Tide. The design tide is the highest which it is estimated occurs in the study area on an average of once a year. The heights of extreme tides have not been recorded at Revere or Nantasket Beaches, but those observed over a long period of record at Boston Harbor provide an excellent indication of the magnitude of fluctuations from the mean. Table K-1, as follows, gives the frequency of occurrence of tide levels which exceeded the mean height by 2.0 feet or more at Boston Harbor, based on 30-1/3 years of record. The design tide elevation at Revere and Nantasket based on this tabulation is 12.0 feet above mean low water and 12.4 feet above mean low water, respectively.

TABLE K-1

TIDES EXCEEDING MEAN HEIGHT
AT BOSTON HARBOR, MASSACHUSETTS

Feet Above MHW	Number of Occurrences[1]	Average Number of Occurrences per year
4.3	1	0.03
4.2	2	0.06
4.1	2	0.06
4.0	2	0.06
3.9	2	0.06
3.8	2	0.06
3.7	3	0.1
3.6	4	0.1
3.5	5	0.2
3.4	7	0.2
3.3	14	0.5
3.2	21	0.7
3.1	32	1.1
3.0	44	1.5
2.9	67	2.2
2.8	83	2.7
2.7	110	3.6
2.6	144	4.8
2.5	205	6.8
2.4	277	9.1
2.3	358	11.1
2.2	463	15.3
2.1	560	18.5
2.0	741	24.5

[1] Equalling or exceeding the stated elevation

2. Design Wave. The height of design wave used for the design of the groins for Plan 2 is the highest wave which can occur at the structure at the time of design tide. Revere Beach is exposed to direct wave action from the open ocean through the southeast quadrant. Therefore, water depths at the structures, and not fetch and wind speed, limit the possible wave height. Design wave height was computed using the solitary wave formula $H = d/1.28$ where H is the wave height and d is the depth of water at time of design tide. Maximum wave heights based on the depths of water encountered at the structures are as tabulated in Table K-2 below:

TABLE K-2

Groin No.[1]	Deep Water (Feet mlw)	Design Depth (d) (Feet)	Wave Ht. (h) (Feet)
1	0.0	12.0	9.4
2	1.5	13.5	10.5
3	2.5	15.5	11.3
4	1.5	10.5	8.2
5	1.0	11.0	8.6
6	1.0	11.0	8.6
7	2.5	9.5	7.4
8	2.5	9.5	7.4

[1]Numbered consecutively from south to north.

3. Groins. Two systems of groin structures for Revere Beach, as included in Plan 2 with 4 each located at two areas with a history of severe wave attack and erosion, are considered as a deferred alternative to the recommended plan of initial beach widening and periodic nourishment, based on experience gained after construction with the better graded material, if alongshore movement of material proves excessive, resulting in losses out of the area so that the project width and alignment cannot be maintained economically. The groins will not reduce offshore losses. The best available data on losses for the existing beach do not indicate that the structures would be economically justified as a means of reducing periodic nourishment requirements, or that they are necessary for the sole purpose of maintaining the project width and alignment. The horizontal shore section of groin structures should ordinarily have a top elevation not lower than the general height of existing or artificial berms of

beaches, and a length not less than the anticipated berm width of the beach. This minimum top elevation has been determined to be 17.0 feet above mean low water for the two northerly groins and 18.0 feet above mean low water for the remaining groins. The intermediate, sloped section should not be steeper than the slope of the existing bottom. The top elevation of the outer section has been established as 1 foot above mean high water (10.0 feet above mean low water) as the minimum practical to afford adequate protection during frequent, once-a-year storms and consistent with economy of construction with armor stones ranging in weight from 3 to 5 tons. For details, see Plates 17 and 18 and Table K-3.

4. Weights and Slopes of Stone Structures. The minimum weights and slopes of armor stone in structures are determined from the formula:

$$W = \frac{W_r H^3}{K_d (Sr - 1)^3 \cot\alpha}$$

Where W = Weight of stone in pounds

W_r = Unit weight of stone in pounds/cu. ft.

K_d = A coefficient; 3.0 for the trunk and 2.5 for the head of structure in shallow water subject to breaking waves.

α = Angle of slope to the horizontal.

H = Wave height at structure.

Minimum weights of armor stones for outer section were determined by criteria for the head in shallow water. Although trunk criteria would allow the use of slightly lighter stone for the outer trunk, it is felt that its use would not reduce the cost of the groin and was, therefore, not practical.

TABLE K-3

Groin No.[1]	Outer Length (Feet)	Outer Slope	Outer Minimum Weight of stone (lbs)	Transition Length (Feet)	Inner[2] Length (Feet)
1	225	2.0:1	7,100	20	280
2	325	2.5:1	7,800	20	230
3	420	2.5:1	9,800	30	165
4	150	1.5:1	6,200	20	300
5	185	1.5:1	7,000	20	280
6	395	1.5:1	7,000	20	75
7	240	1.5:1	4,800	20	160
8	270	1.5:1	4,800	20	120

[1] Numbered consecutively from south to north.

[2] Inner sections of groins are all on a slope of 1.5:1 with armor stone ranging between 1.0 and 1.5 tons.

The filter stone immediately beneath the armor stone was computed to contain assorted sizes with at least one-half the stone having weights equal to 10 percent of the armor stone weight and the remainder in smaller quarry-run sizes. The top width of the groins and the thickness of armor stone are at least twice the dimension of the side of a cube of stone having the specified weight of the armor stone. Quarry-run stone up to 100 pounds in weight was selected for bedding.

5. Sandfill. The berm widths and beach slopes as shown on Plates 17 through 21 are based on those found to be stable within the area and to provide sufficient width and depth over massive, stepped or sloped concrete seawalls to minimize losses from scouring during infrequent storms with a flood level greater than the design storm. A 50-foot wide level berm was considered adequate at Revere Beach; however, a 75-foot level berm was used for Nantasket Beach with a more severe direct exposure to northeast storms. The characteristics of the sandfill should be somewhat coarser than exist on the present beaches. It should consist of a well-graded material having a median diameter of not less than .40 mm., consistent within practical and economic limits. Maximum diameters can range as high as 2 mm. and still remain within the classification of medium beach sand satisfactory for bathing purposes.

The sandfill should be obtained from either good land borrow, which is available in sufficient quantities within practical distances for large-scale operations for these projects, or from offshore borrow areas found to have similar characteristics. This type of material should be available within the range of economy of construction by large-scale transportation and direct pump-out operations of a large dredge. The proposed beach slopes vary from as steep as 1 vertical on 15 horizontal above mean high water to as flat as 1 vertical on 40 horizontal below mean low water. The beach fill can be placed on a slightly steeper slope and allowed to assume its natural slope under wave action. In these areas exposed to frequent, moderate wave action, this grade of sandfill should, through natural processes, attain no flatter slopes than specified in the design and be substantially more stable and resistant to movement by wave-induced forces and should minimize offshore losses or displacement alongshore. In general, this furnishes a maximum width from mean high water to backshore structures of 185 feet for Revere Beach and 190 feet for Nantasket Beach. For the purpose of detailed design of the beach fill, the investigation of materials on the beach and in proposed borrow areas should be supplemented when plans and specifications are being prepared.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

September 13, 1966

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

This is our conservation and development report on the beach erosion control project under consideration for Revere Beach, Suffolk County, Massachusetts, and is in response to Mr. Leslie's April 19, 1966 letter describing the project plans you are considering. Your studies are being made under the authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. Our report was prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.), in cooperation with the Massachusetts Division of Fisheries and Game and the Division of Marine Fisheries and has their concurrence as indicated by letters dated September 2, 1966.

It is our understanding that the project will consist of widening 13,000 feet of Revere Beach. The beach will be widened to 185 feet above mean high water with a general backshore elevation of 18 feet above mean low water. Groins will be located at eight strategic positions to reduce littoral movement of beach sand. These groins will be constructed on a deferred basis if future experience demonstrates their need. We also understand that these groins will be smooth capped as recommended in our report of February 7, 1962. Public access to these groins will be provided.

We understand that borrow areas for beach fill material have not been selected. One possible source of beach fill under consideration is an irregularly shaped offshore borrow area located one-half mile northeast of Roughans Point. Borrow areas located further out to sea are also possibilities. Upland borrow areas are also being considered.

The project as planned will have no significant adverse effects on fish and wildlife resources in the area. Neither does it present any outstanding opportunities for fish and wildlife development. The smoothcapped groins will provide some sport fishing opportunities during high and intermediate tidal stages.

We have no objection to the use of the offshore borrow area one-half mile east of Roughans Point for beach fill.

Our February 7, 1962 report recommended that no fill material be dredged from the Pines River or adjoining wetlands. This recommendation is still applicable.

Please advise us of specific borrow areas that may be considered (other than the one offshore of Roughans Point) so that we can determine what, if any, effects the use of such areas might have on fish and wildlife resources.

Sincerely yours,

Eugene E. Crawford

Acting Regional Director
Bureau of Sport Fisheries & Wildlife

Robert T. Hanlett

Regional Director
Bureau of Commercial Fisheries

APPENDIX L

REPORT OF THE UNITED STATES FISH AND WILDLIFE SERVICE AND COMMENTS OF OTHER AGENCIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
59 Temple Place
Boston, Massachusetts

February 7, 1962

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This is our conservation and development report on the effects the beach erosion control project under consideration for Nantasket Beach, Massachusetts will have on fish and wildlife resources. It was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661, et seq.), in cooperation with the Massachusetts Division of Fisheries and Game and the Massachusetts Division of Marine Fisheries. Both agencies concur in this report as indicated in their letters of January 30 and January 24, respectively.

Restoration and widening of about 1600 yards of the portion of the beach owned by the Metropolitan District Commission, the south end of the beach, and the construction of groins will be considered. Beach fill materials will be obtained from offshore by hydraulic dredge, from behind, that is, immediately west of the beach fill area, or it may be trucked in.

Hingham Bay is an important duck wintering area, predominantly for scaup ducks, but also for black ducks. The intertidal flats adjoining the Weir River immediately west of the portion of the beach to be filled are of high value to waterfowl and often heavily used by feeding and resting waterfowl. Although this Weir River area is polluted, clams are sometimes harvested and processed to eliminate contamination and then marketed. This is also true of the White Head Flats.

Placement of fill on the beach and construction of groins will not cause significant fish and wildlife resource losses. Neither will dredging offshore of Nantasket Beach or in the Weir River channel or trucking in fill materials cause significant resource losses.

If the groins extend to deep water they would provide sport-fishing opportunities, and public access should be provided to the inshore end of the groins. Stones forming the top of the groins should be placed so as to form a flat surface with a minimum of voids in order to provide safe walking.

Dredging in the intertidal flats or marshes adjacent to the Weir River channel, that is, behind and west of the portion of the beach to be restored or in the White Head Flats will cause significant losses of waterfowl habitat. No dredging for beach fill materials should be undertaken in these wetlands. This will also preserve the rather limited clam resources there.

It is recommended--

1. That if the project includes groins, they be constructed with a smooth, safe surface and that public access be provided to the inshore ends if the groins extend to deep water.

2. That no dredging for the purpose of obtaining beach fill material be undertaken in the intertidal flats or marshes adjacent to Weir River channel or in the White Head Flats.

We will conduct no additional studies of the project unless plans are subsequently developed that include measures not considered herein.

Sincerely yours,

M. A. Marston
Acting Regional Director
Bureau of Sport Fisheries & Wildlife

John T. Gharrett
Regional Director
Bureau of Commercial Fisheries

The Commonwealth of Massachusetts

Metropolitan District Commission

20 Somerset Street, Boston 02108

September 28, 1966

Colonel Remi O. Renier
U. S. Army Engineers Division, N. E.
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

The following is an extract from the records of the meeting of this Commission held on September 28, 1966:

> "Letter of U. S. ~~Army Engineers~~ Division, N.E., August 23, 1966, outlining a course of action for a Cooperative Beach Erosion Control Study for Revere and Nantasket Beaches.
>
> After consideration and a full discussion of the matter, the Commission V O T E D to approve the suggested course of action outlined in their letter of August 23, 1966, and to recommend that the U. S. Army Engineers proceed accordingly."

The Commission also wanted you to know that it is their intention to request the Legislature for the funds necessary to meet the Commission's share of the cost of the proposed construction.

Very truly yours,

Richard I. Furbush

RICHARD I. FURBUSH
Secretary

mb

The Commonwealth of Massachusetts

Metropolitan District Commission

20 Somerset Street, Boston 02108

Howard Whitmore, Jr.
Commissioner

April 22, 1968

Colonel Remi O. Renier
Division Engineer
N.E. Division Corps of Engineers
U. S. Army Engineers
424 Trapelo Road
Waltham, Massachusetts

Dear Colonel Renier:

Mr. Cecil Wentworth of your office and Benjamin W. Fink, Director of Park Engineering and Chief Park Engineer for the Metropolitan District Commission, have reviewed the recommended improvements for beach erosion control for Revere and Nantasket Beaches as contained in the public notice dated April 8, 1968. The Commission is in favor of these projects and recommends approval by the Board of Rivers and Harbors Engineers in Washington. The conditions at both beaches are poor and the Commission hopes that quick action may be taken so that the beaches may be restored for their full recreational use.

The Commission has available at the present time $1,200,000 for the work to be done at Revere Beach and $1,000,000 for the work to be done at Nantasket Beach. Inasmuch as the Federal Government will pay fifty percent of the project and the Commonwealth will pay fifty percent of the project, the Commonwealth already has appropriated, under Chapter 786, Acts of 1967, Account No. 9038-01, $2,200,000. This appropriation will expire on June 30, 1972. It is noted that the Federal Government will participate at one-half the cost of periodic nourishment for the first ten years of project life and that no groin structures are contemplated at this time; however, after ten years, benefits and techniques will be reevaluated.

Sincerely yours,

HOWARD WHITMORE, JR.
Commissioner

HW/e

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF REVERE AND NANTASKET BEACHES, MASSACHUSETTS

Information Called for by Senate Resolution 148, 85th Congress
Adopted 28 January 1958

1. The study covers Revere Beach from Roughan's Point to the mouth of the Saugus River, a distance of approximately 3-1/2 miles, and Nantasket Beach from Atlantic Hill to Phipps Street, a distance of approximately 1-1/2 miles. The problem consists of the erosion of the beaches due to offshore losses combined with the drifting of the existing beach material and the insufficient supply of replenishment material. Revere Beach is exposed to direct wave attack from the southeast quadrant. Storms originating in the east and northeast quadrant attack the beach only after refraction and diffraction of the storm waves around Nahant. Nantasket Beach is directly exposed to waves approaching from the northeast through the southeast. The mean range of tide at Revere Beach is 9.0 feet and at Nantasket Beach is 9.4 feet. The predicted spring tides at Boston Harbor, which closely correlates the area of study, range up to about 12.0 feet, with actual heights of extreme tides having been recorded up to 15.0 feet above mean low water.

2. Improvements Considered. Plans were developed for protection and improvement of the study areas as follow:

a. Revere Beach. *In lieu of the project authorized by* the River and Harbor Act of 1954, providing a beach of increased width, fronting the Metropolitan District Commission, by direct placement of suitable sandfill and periodic nourishment at suitable intervals of time to maintain project dimensions. A better graded material will be used than was utilized in the partial construction of the authorized project by the Commonwealth of Massachusetts.

b. Nantasket Beach. Provide beach widening by direct placement of suitable sandfill and periodic nourishment at suitable intervals of time to maintain project dimensions.

3. Conclusion and Recommendations. The Division Engineer concludes that the most practical and economical method of protection

and restoration of the beaches is as stated. He therefore recommends that beach erosion control projects be adopted for Revere and Nantasket Beaches authorizing Federal participation to the effect of one-half the cost of the projects, described as follows:

a. Revere Beach. In lieu of the project authorized by the River and Harbor Act of 1954, provide beach widening by direct placement of suitable sandfill along about 13, 000 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a protective and recreational beach averaging 185 feet in width behind the mean high water line, a width commensurate with present and long-range comfortable recreational use requirements, and providing a more effective protective improvement fronting massive concrete stepped walls and structures.

b. Nantasket Beach. Provide beach widening by direct placement of suitable sandfill along about 6, 800 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 17 feet above mean low water, thus furnishing a protective and recreational beach width averaging 190 feet behind the mean high water line.

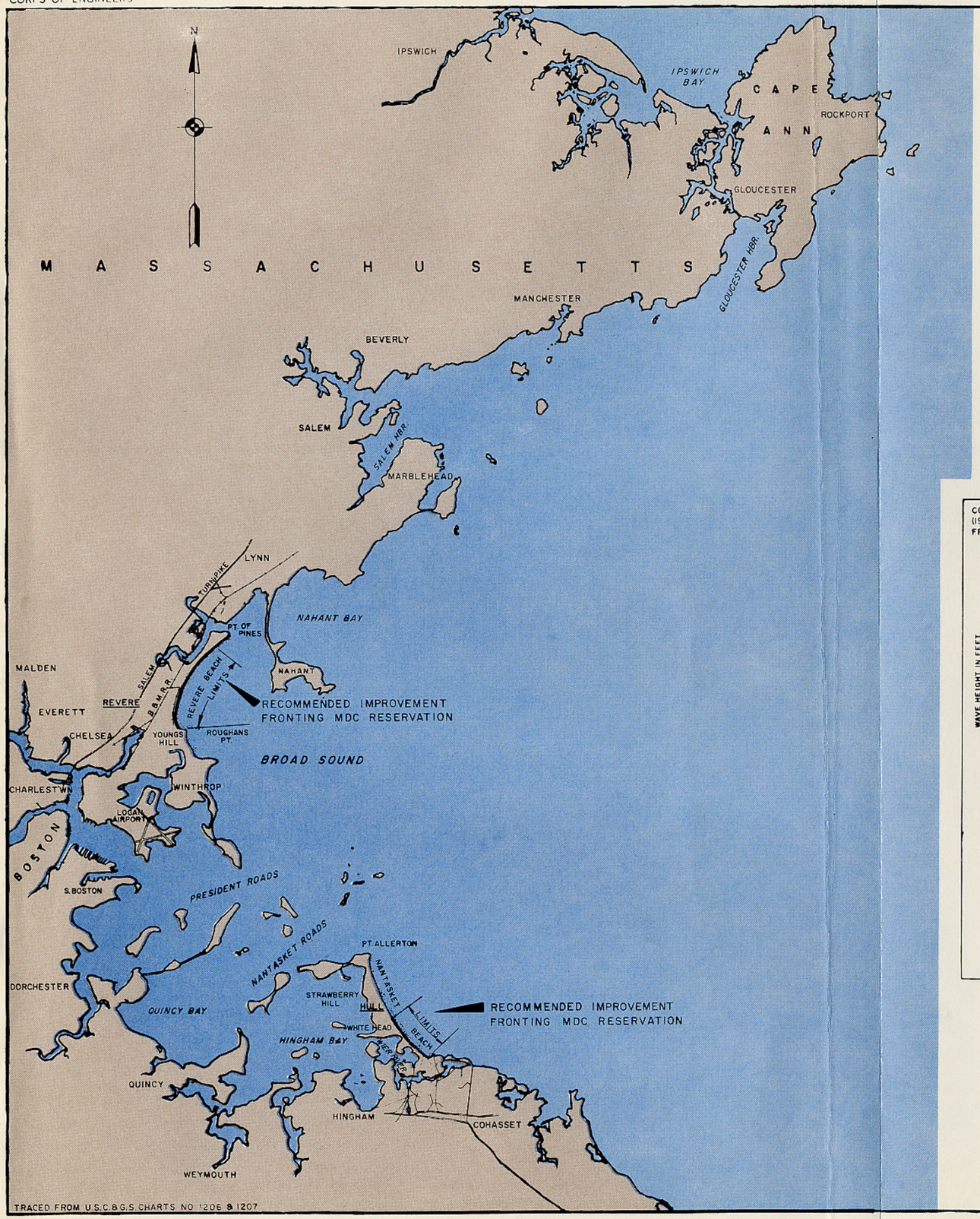
4. The Division Engineer further recommends that Federal participation be authorized for both projects in the amount of one-half the cost of periodic nourishment which would involve deposition of suitable sand on the beaches at suitable intervals of time for the first 10 years of the project life. The periodic nourishment would be accomplished by the United States after receipt of the local share. After the first 10 years of project life, benefits and techniques would be reevaluated.

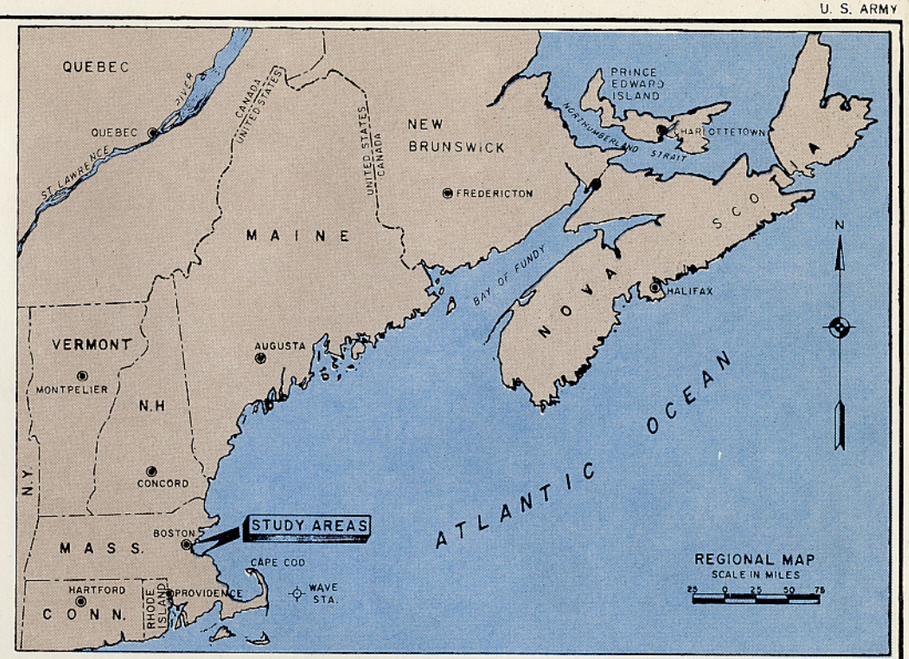
5. The presently estimated first cost of these projects is $2, 400, 000 for Revere Beach, and $2, 000, 000 for Nantasket Beach, to be borne jointly by the United States and the Commonwealth of Massachusetts. The Federal share of the first cost of the projects is established at fifty percent or $1, 200, 000 for Revere Beach, and $1, 000, 000 for Nantasket Beach. The estimated annual amount of Federal participation for periodic nourishment at each beach is $25, 000.

6. Discussion. The benefits were computed on the basis of promoting and encouraging healthful recreation for the people by protecting and improving public beaches and preventing direct damages to public property. All benefits evaluated are non-Federal public benefits. The annual benefits were determined to be $620,000 for Revere Beach and $417,250 for Nantasket Beach. The annual charges of $147,800 for Revere Beach and $131,400 for Nantasket Beach give benefit to cost ratios of 4.2 and 3.2. Changing the economic life of the projects to 100 years would increase the benefit to cost ratios to 4.5 for Revere Beach and 3.5 for Nantasket Beach.

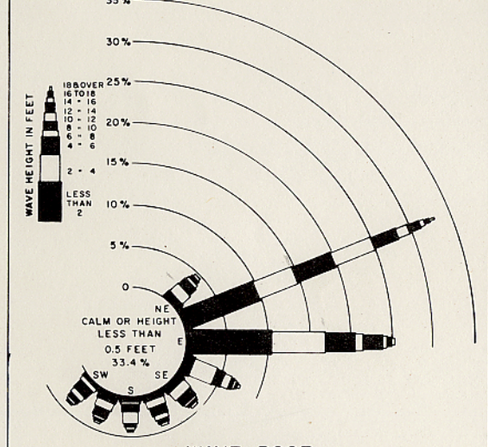
CORPS OF ENGINEERS

U. S. ARMY





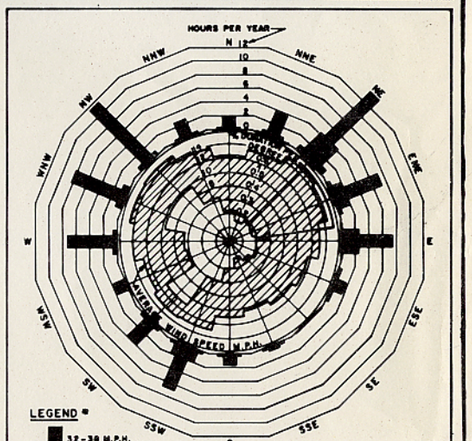
COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION. FROM BEACH EROSION BOARD TECH. MEMO. NO. 55.



WAVE ROSE

OFF NAUSET BEACH, CAPE COD, MASS.

(LAT. 41° 50' N, LONG. 69° 30' W)



WIND ROSE

LOGAN AIRPORT, BOSTON, MASS.

OCTOBER 1949 – SEPTEMBER 1959

10 YEAR RECORD

* DURATION FOR EACH RANGE OF WIND SPEEDS IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH.

NOTE:

PERCENT DURATION PER DEGREE IS THE AVERAGE PERCENT DURATION OBSERVED FOR EACH 16 POINTS OF THE COMPASS DIVIDED BY 22 1/2 DEGREES.

SCALE IN FEET

8000 0 8000 16000

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY A.D.C.	TR. BY A.D.C.	CK. BY T.C.B

SUBMITTED: Cecil P. Wentworth, PROJECT ENGINEER

Oscar E. Gray, CHIEF, COASTAL DEVEL. SECT.

APPROVAL RECOMMENDED: CHIEF, PLANNING BRANCH

APPROVED: CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. LOCATION MAP

TO ACCOMPANY REPORT DATED. 28 MARCH 1968

SCALE

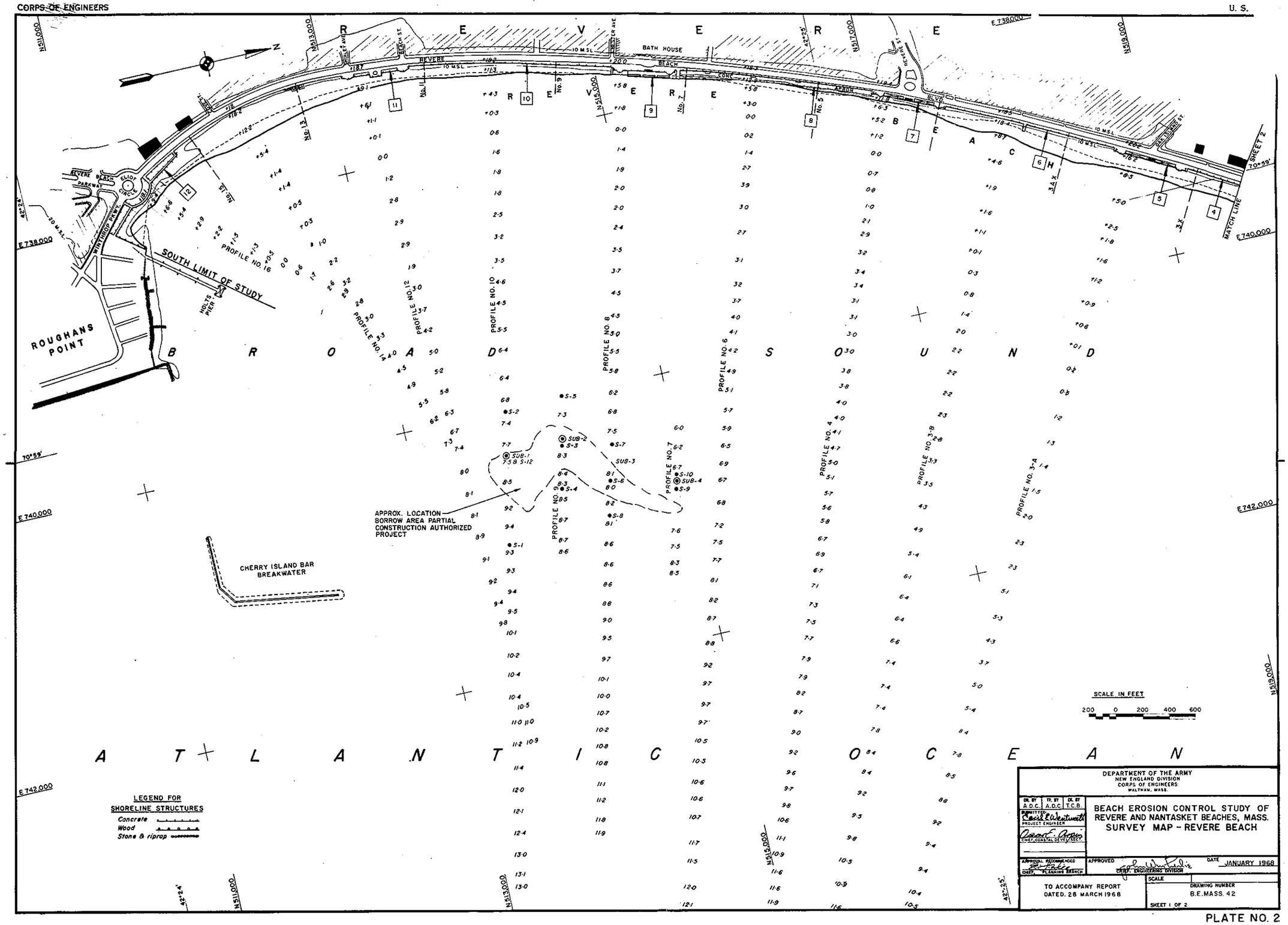
DRAWING NUMBER B.E. MASS. 41

SHEET 1 OF 1

PLATE NO. 1

CORPS OF ENGINEERS

U. S.



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.O.C.	A.O.C.	T.C.B.

SUBMITTED: Cecil C. Westervelt, PROJECT ENGINEER
Chief, Coastal Devel. Sect.
APPROVAL RECOMMENDED: Chief, Planning Branch
APPROVED: Chief, Engineering Division
DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. SURVEY MAP - REVERE BEACH

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

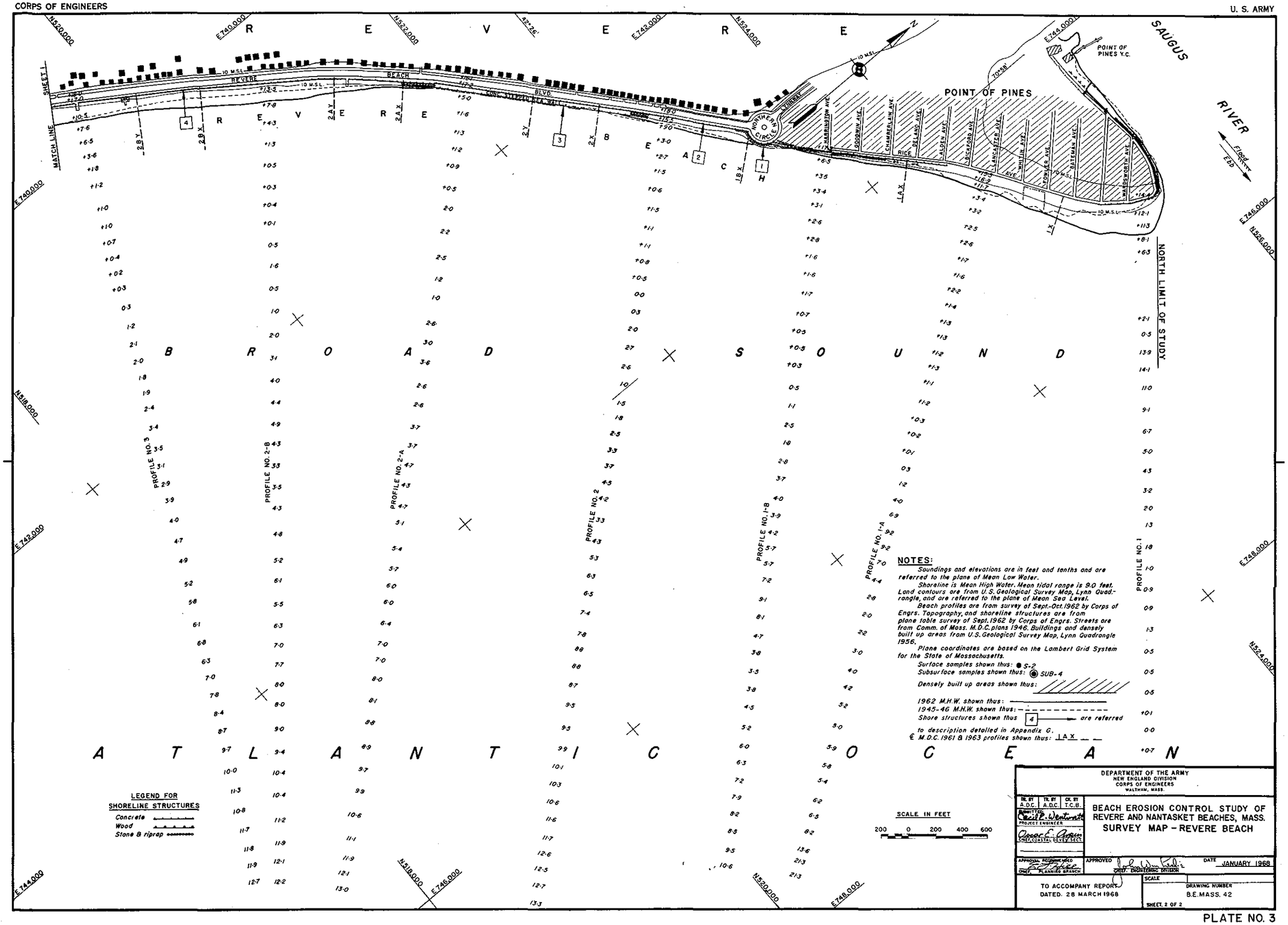
DRAWING NUMBER B.E.MASS. 42

SHEET 1 OF 2

PLATE NO. 2

CORPS OF ENGINEERS

U. S. ARMY



LEGEND FOR SHORELINE STRUCTURES

Concrete

Wood

Stone & riprap

NOTES:

Soundings and elevations are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Mean tidal range is 9.0 feet. Land contours are from U.S. Geological Survey Map, Lynn Quadrangle, and are referred to the plane of Mean Sea Level.

Beach profiles are from survey of Sept.-Oct. 1962 by Corps of Engrs. Topography, and shoreline structures are from plane table survey of Sept. 1962 by Corps of Engrs. Streets are from Comm. of Mass. M.D.C. plans 1946. Buildings and densely built up areas from U.S. Geological Survey Map, Lynn Quadrangle 1956.

Plane coordinates are based on the Lambert Grid System for the State of Massachusetts.

Surface samples shown thus: ● S-2

Subsurface samples shown thus: ◉ SUB-4

Densely built up areas shown thus:

1962 M.H.W. shown thus: ———

1945-46 M.H.W. shown thus: – – – – – –

Shore structures shown thus [4] ——► are referred to description detailed in Appendix G.

℄ M.D.C. 1961 & 1963 profiles shown thus: 1A X

SCALE IN FEET

200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: Cecil P. Wentworth, PROJECT ENGINEER

Owen C. Quinn, CHIEF COASTAL SURVEY SECT.

APPROVAL RECOMMENDED: [illegible], CHIEF, PLANNING BRANCH

APPROVED: [illegible], CHIEF, ENGINEERING DIVISION

DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. SURVEY MAP - REVERE BEACH

TO ACCOMPANY REPORT DATED: 28 MARCH 1968

SCALE

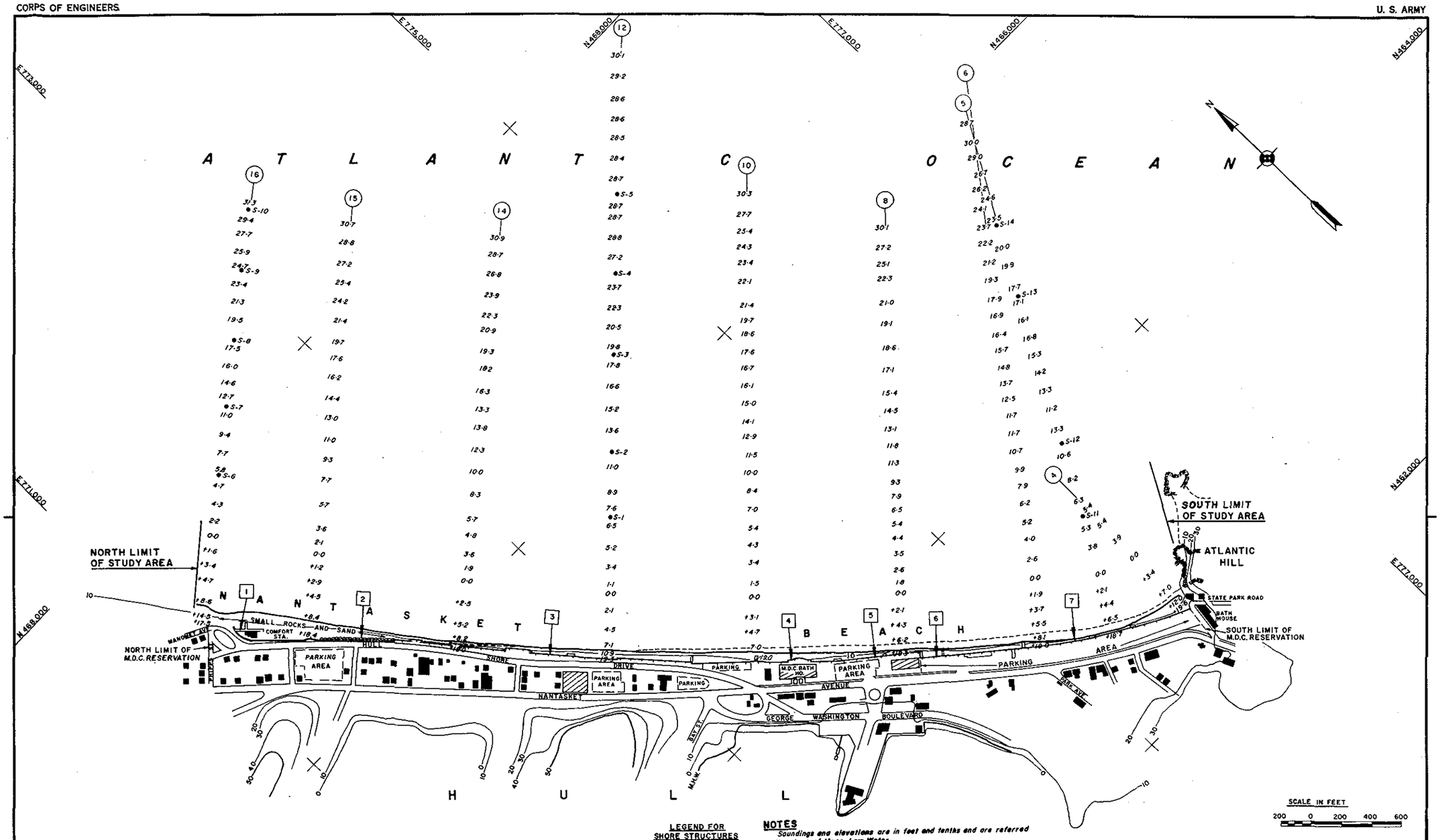
DRAWING NUMBER: B.E. MASS. 42

SHEET 2 OF 2

PLATE NO. 3

CORPS OF ENGINEERS

U. S. ARMY



SCALE IN FEET

200 0 200 400 600

LEGEND FOR SHORE STRUCTURES

Concrete wall

Stone or riprap

NOTES

Soundings and elevations are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Mean tidal range is 9.4 feet. Land contours are from U.S. Geological Map, Hull Quadrangle, and are referred to the Plane of Mean Sea Level.

Beach profiles, topography and shoreline structures are from survey of April, 1963 by Corps of Engrs. Buildings and streets west of Hull Shore Drive and Nantasket Ave. from aerial photos by Corps of Engrs. Nov. 1963 and from previous surveys.

Plane coordinates are based on the Lambert Grid System for the State of Massachusetts.

Surface samples shown thus: ● S-2

1963 M.H.W. shown thus:

1945-46 M.H.W. shown thus:

Profiles shown thus: (3)

Shore structures shown thus: [4] are referred to description detailed in Appendix G.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CH. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED
Cecil B. Wentworth
PROJECT ENGINEER

Oscar E. Monnett
CHIEF, COASTAL DEVEL. SECT.

APPROVAL RECOMMENDED
Fred C. Fiske
CHIEF, PLANNING BRANCH

APPROVED
CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.
SURVEY MAP - NANTASKET BEACH

TO ACCOMPANY REPORT
DATED: 28 MARCH 1968

SCALE

DRAWING NUMBER
B.E. MASS. 43

SHEET 1 OF 1

PLATE NO. 4

FEET

PROF. STA. 200 0 200 1000 2000 3000 4000 5000

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

+15 +10 +5 0 -5 -10 -15

Rice Ave.
Conc. sea wall
M.H.W. El. +9.0
M.L.W.
No. 1962 edge.
PROFILE I
BLACK ROCKS LIGHT
No. 1946 edge.

Rice Ave.
M.H.W. El. +9.0
M.L.W.
PROFILE I-A

Conc. sea wall
Riprap
M.H.W. El. +9.0
M.L.W.
PROFILE I-B

℄ IS ℄ RICE AVE.
0 200 400 600
+15 +10 +5 0
PROFILE I-X

Conc. sea wall
+20 +15 +10 +5 0
PROFILE I-AX

℄ IS E. SIDE BLVD.
0
Conc. sea wall
Riprap
+15 +10 +5 0
PROFILE I-BX

LEGEND

1945-1946	———	Corps of Engrs.
Oct. 1961	·····	M.D.C.
Sept.-Oct. 1962	———	Corps of Engrs.
Jan. 1963	-·-·-·-	M.D.C.

BEACH EROSION CONTROL STUDY OF
REVERE AND NANTASKET BEACHES, MASS.

COMPARATIVE PROFILES - REVERE BEACH

SHEET 1 OF 5 — SCALE IN FEET — JANUARY 1968

HOR. 200 0 200 400 600

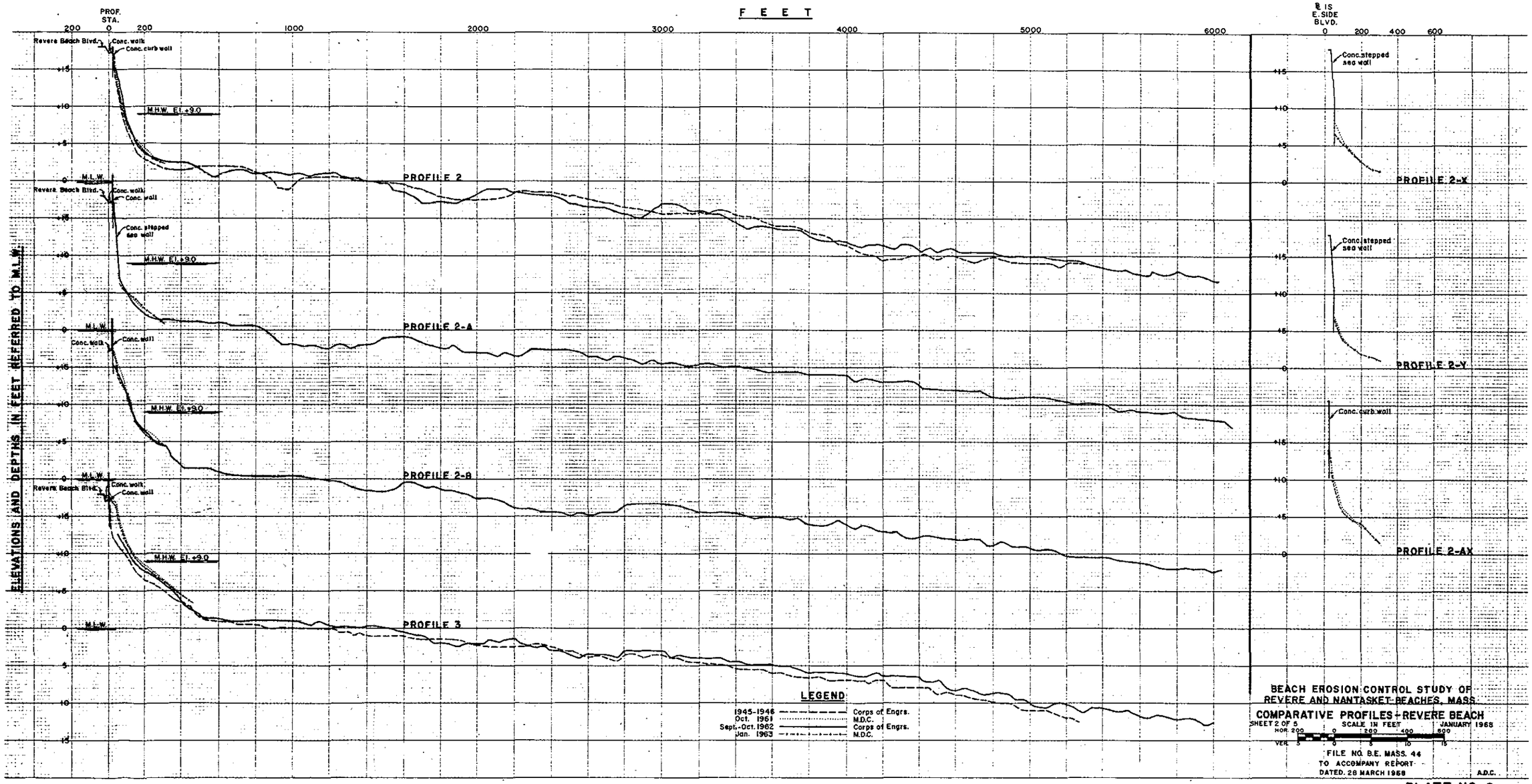
VER. 5 0 5 10 15

FILE NO. B.E. MASS. 44

TO ACCOMPANY REPORT
DATED 28 MARCH 1968

A.O.C.

PLATE NO. 5



BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

COMPARATIVE PROFILES - REVERE BEACH

SHEET 2 OF 5 SCALE IN FEET JANUARY 1968

HOR. 200 0 200 400 600

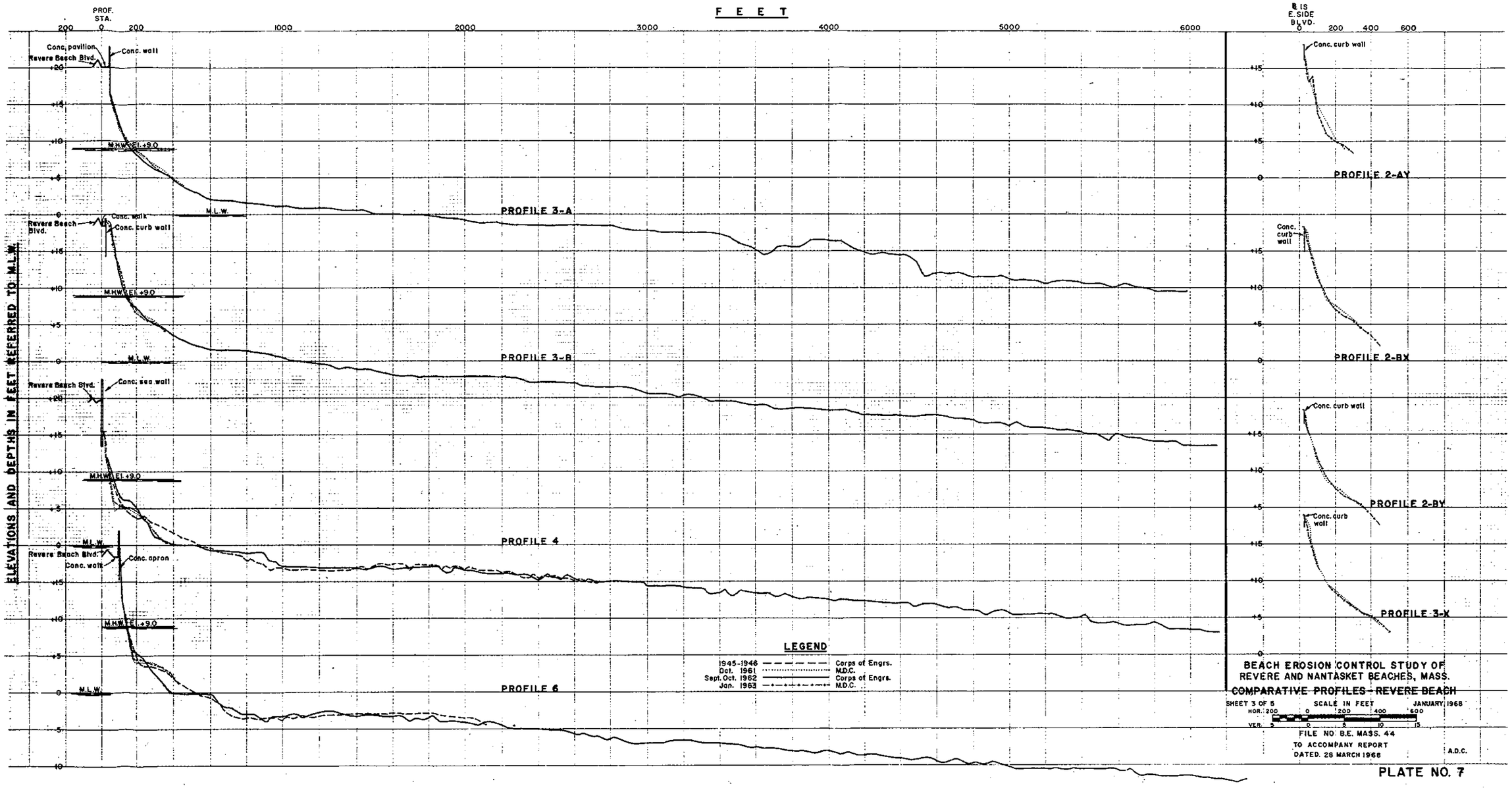
VER. 5 0 5 10 15

FILE NO. B.E. MASS. 44

TO ACCOMPANY REPORT DATED. 28 MARCH 1968

A.D.C.

PLATE NO. 6



BEACH EROSION CONTROL STUDY OF
REVERE AND NANTASKET BEACHES, MASS.
COMPARATIVE PROFILES - REVERE BEACH

SHEET 3 OF 5 SCALE IN FEET JANUARY 1968

HOR. 200 0 200 400 600
VER. 5 0 5 10 15

FILE NO. B.E. MASS. 44
TO ACCOMPANY REPORT
DATED. 28 MARCH 1968

A.D.C.

PLATE NO. 7

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

FEET

PROF. STA. 200 0 200 1000 2000 3000 4000 5000 6000

Revere Beach Blvd. Conc. pavilion Conc. curb wall Conc. ramp M.H.W. El. +9.0 M.L.W.

PROFILE 8

Revere Beach Blvd. M.H.W. El.+9.0 M.L.W.

PROFILE 10

Revere Beach Blvd. Conc. pavilion Conc. sea wall M.H.W. El.+9.0 M.L.W.

PROFILE 12

Conc. walk Revere Beach Blvd. M.H.W. El.+9.0 M.L.W.

PROFILE 14

Revere Beach Blvd. Grass Conc. walk Conc. sea wall M.H.W. El.+9.0 M.L.W.

PROF. STA. 0 1000 2000

PROFILE 16

℄ IS E. EDGE PKWY. 0 200 400

Conc. curb wall

PROFILE 3-AX

0 200 400

Conc. sea wall

PROFILE 3-BX

Conc. sea wall

PROFILE 5

Conc. sea wall

PROFILE 7

Conc. sea wall

PROFILE 9

Conc. sea wall

PROFILE 11

Walk

PROFILE 13

Walk

PROFILE 15

LEGEND

1945-1946	Corps of Engrs.	
Oct. 1961	M.D.C.	
Sept.-Oct. 1962	Corps of Engrs.	
Jan. 1963	M.D.C.	

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

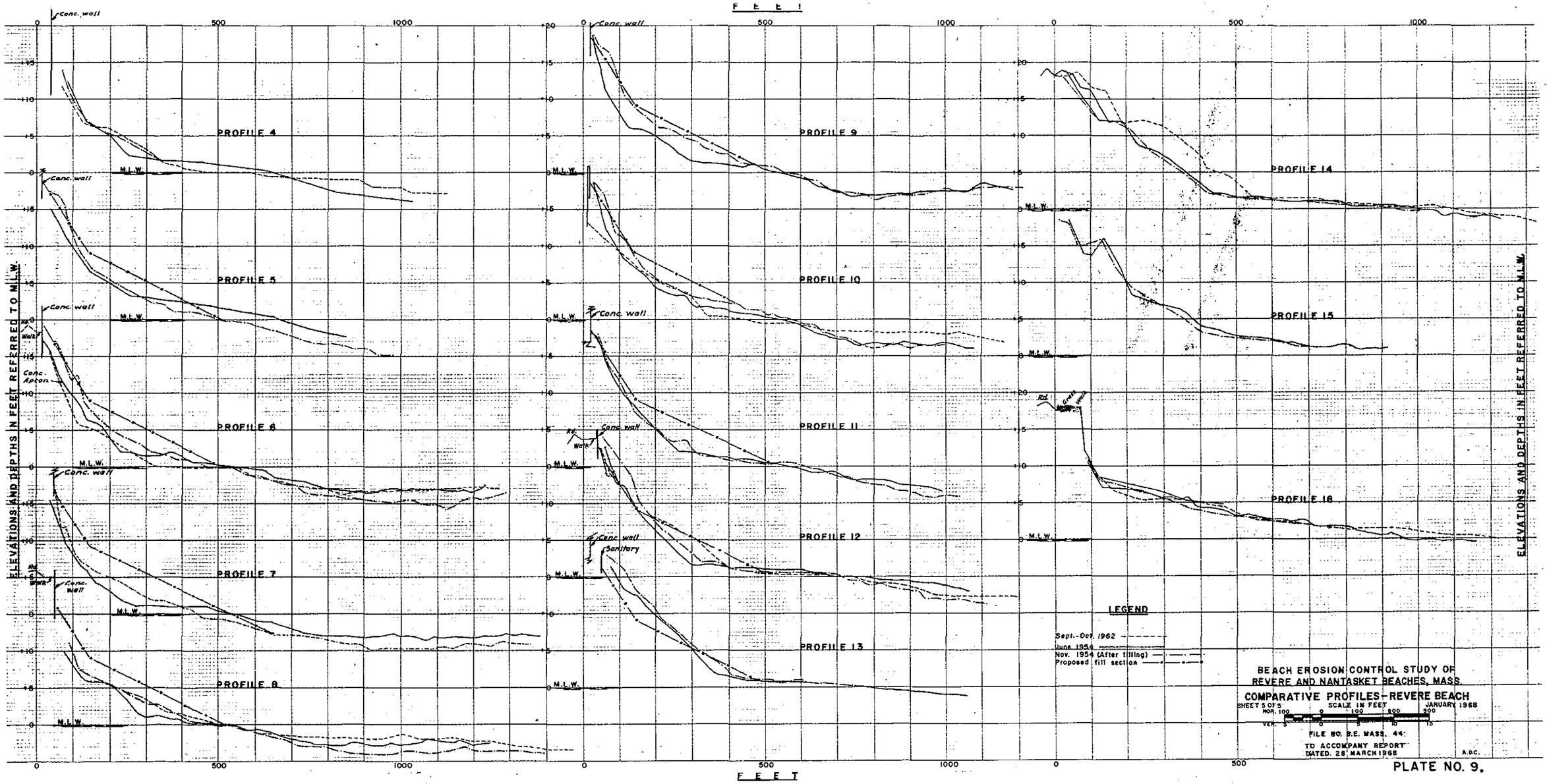
COMPARATIVE PROFILES - REVERE BEACH

SHEET 4 OF 5 SCALE IN FEET HOR. 200 0 200 400 800 VER. 5 0 5 10 15 JANUARY 1968

FILE NO. B.E. MASS. 44 TO ACCOMPANY REPORT DATED 28 MARCH 1968

A.D.C.

PLATE NO. 8



BEACH EROSION CONTROL STUDY OF
REVERE AND NANTASKET BEACHES, MASS.

COMPARATIVE PROFILES - REVERE BEACH

SHEET 5 OF 5 — SCALE IN FEET — JANUARY 1968

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

FILE NO. B.E. MASS. 44

TO ACCOMPANY REPORT
DATED. 28 MARCH 1968

A.D.C.

PLATE NO. 9.

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

FEET

PROF. STA.

200 0 200 1000 2000 3000

+20 +15 +10 +5 0 -5 -10 -15 -20 -25 -30

Conc. sea wall

M.H.W. Elev. 9.4

M.L.W. Elev. 0.0

PROFILE 4

Conc. sea wall

M.H.W. Elev. 9.4

M.L.W. Elev. 0.0

PROFILE 5

Conc. sea wall

M.H.W. Elev. 9.4

M.L.W. Elev. 0.0

PROFILE 6

PROF. STA.

0 1000 2000 3000

+15 +10 +5 0 -5 -10 -15 -20 -25 -30

Conc. sea wall

M.H.W. Elev. 9.4

M.L.W. Elev. 0.0

PROFILE 8

Conc. sea wall

Conc. ramp

M.H.W. Elev. 9.4

M.L.W. Elev. 0.0

PROFILE 10

LEGEND

1945-46 Corps of Engrs. ---------

1963

Small rocks and sand

Sand -1963

Small rocks or riprap

BEACH EROSION CONTROL STUDY OF
REVERE AND NANTASKET BEACHES, MASS.

COMPARATIVE PROFILES-NANTASKET BEACH

SHEET 1 OF 2 SCALE IN FEET JANUARY 1968

HOR. 200 0 200 400 600

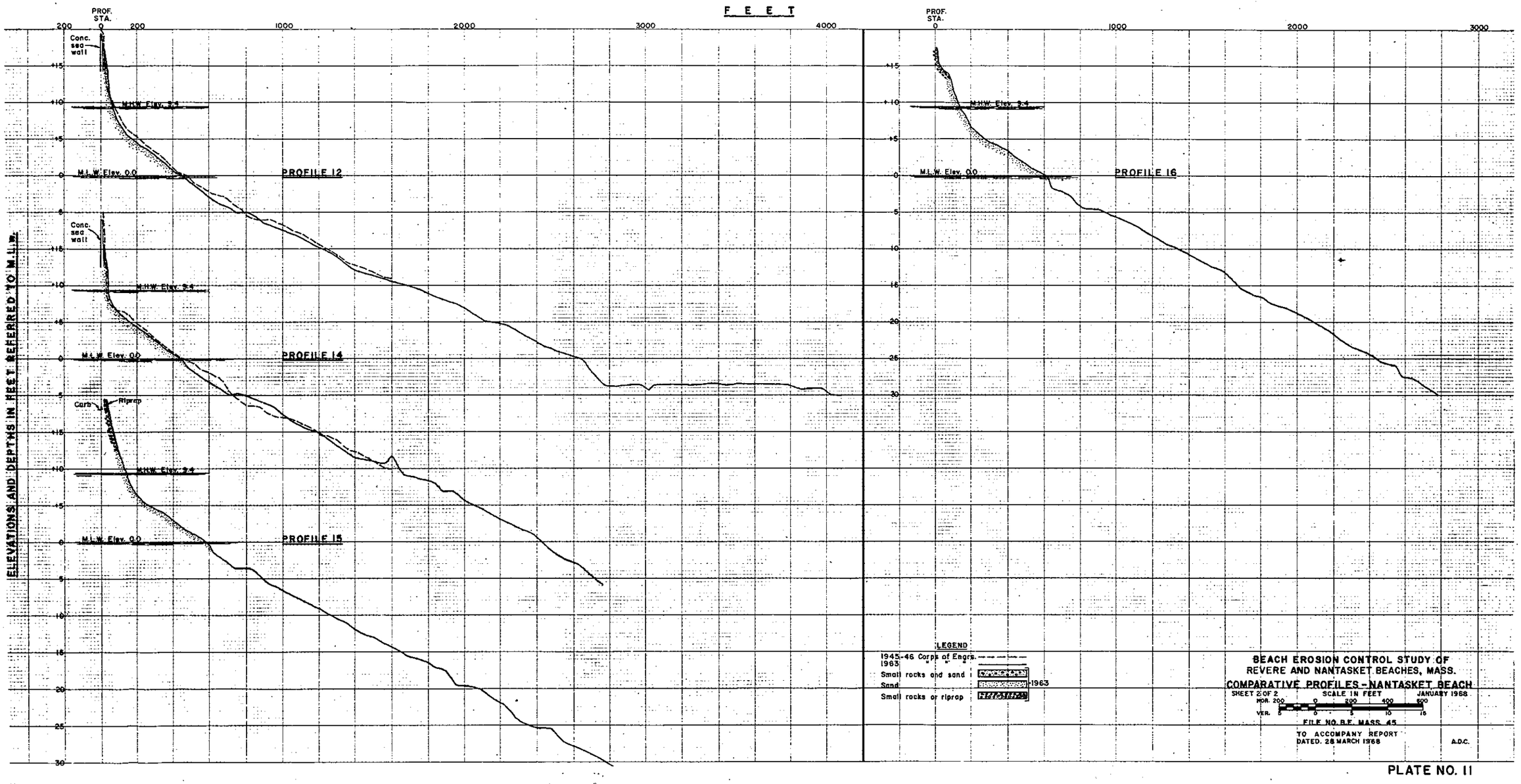
VER. 5 0 5 10 15

FILE NO. BP MASS. 45

TO ACCOMPANY REPORT DATED: 28 MARCH 1968

A.D.C.

PLATE NO. 10



BEACH EROSION CONTROL STUDY OF
REVERE AND NANTASKET BEACHES, MASS.

COMPARATIVE PROFILES - NANTASKET BEACH

SHEET 2 OF 2 — SCALE IN FEET — JANUARY 1968

HOR. 200 0 200 400 600

VER. 5 0 5 10 15

FILE NO. B.E. MASS. 45

TO ACCOMPANY REPORT
DATED. 28 MARCH 1968

A.D.C.

PLATE NO. 11

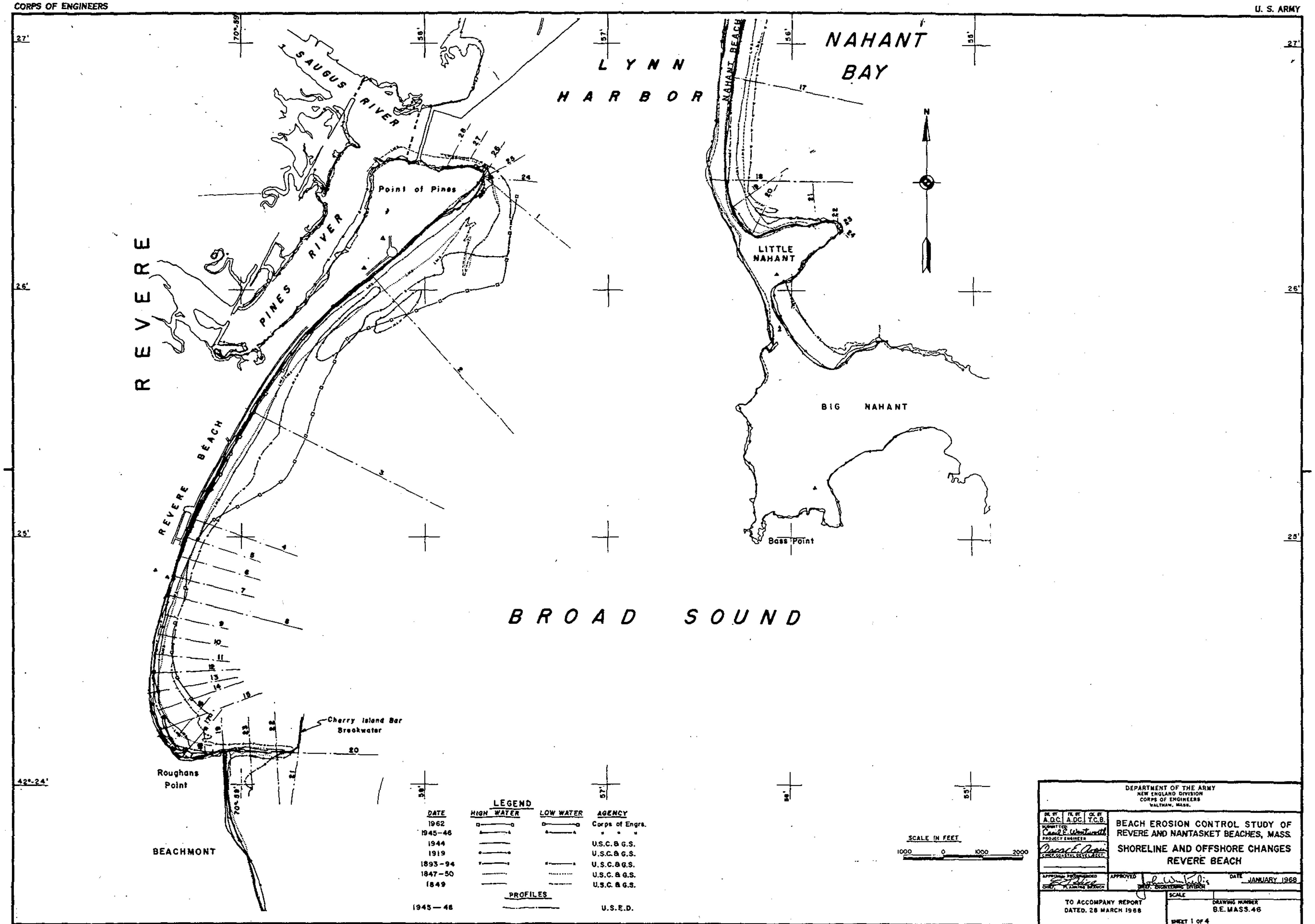
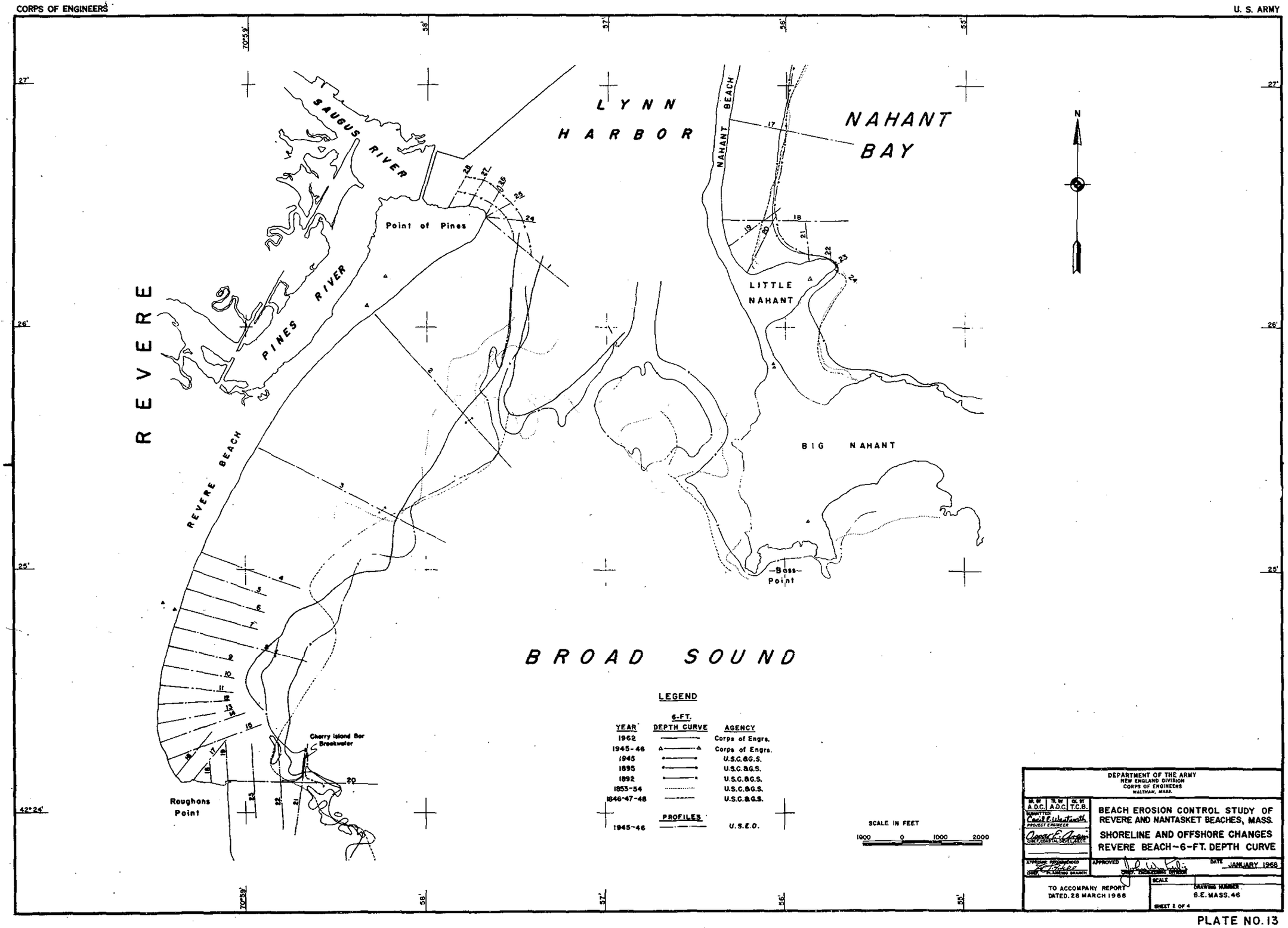

CORPS OF ENGINEERS
U. S. ARMY
NAHANT BAY
LYNN HARBOR
NAHANT BEACH
SAUGUS RIVER
PINES RIVER
Point of Pines
REVERE
REVERE BEACH
LITTLE NAHANT
BIG NAHANT
Bass Point
BROAD SOUND
Cherry Island Bar Breakwater
Roughans Point
BEACHMONT
N
SCALE IN FEET
1000 0 1000 2000
LEGEND
DATE | HIGH WATER | LOW WATER | AGENCY
1962 Corps of Engrs.
1945-46
1944 U.S.C.& G.S.
1919 U.S.C.& G.S.
1893-94 U.S.C.& G.S.
1847-50 U.S.C.& G.S.
1849 U.S.C.& G.S.
PROFILES
1945—46 U.S.E.D.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.
SHORELINE AND OFFSHORE CHANGES
REVERE BEACH
PROJECT ENGINEER
APPROVED
DATE JANUARY 1968
TO ACCOMPANY REPORT DATED, 28 MARCH 1968
DRAWING NUMBER B.E.MASS.46
SHEET 1 OF 4

PLATE NO. 12

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

YEAR	6-FT. DEPTH CURVE	AGENCY
1962		Corps of Engrs.
1945-46	△——△	Corps of Engrs.
1945	•——•	U.S.C.&G.S.
1895	•——•	U.S.C.&G.S.
1892	•——•	U.S.C.&G.S.
1853-54	·····	U.S.C.&G.S.
1846-47-48	———	U.S.C.&G.S.

PROFILES

1945-46	—·—·—	U.S.E.D.

SCALE IN FEET

1000 0 1000 2000

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: Cecil E. Edwards, PROJECT ENGINEER
CHIEF, COASTAL DEVELOPMENT SECT.

APPROVED RECOMMENDED: Fisher, CHIEF, PLANNING BRANCH

APPROVED: [signature], CHIEF, ENGINEERING DIVISION

DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

SHORELINE AND OFFSHORE CHANGES REVERE BEACH-6-FT. DEPTH CURVE

TO ACCOMPANY REPORT DATED: 28 MARCH 1968

SCALE

DRAWING NUMBER: B.E. MASS. 46

SHEET 2 OF 4

PLATE NO. 13

CORPS OF ENGINEERS

U. S. AR.

70°-59'

58'

57'

56'

55'

27'

26'

25'

42°-24'

SAUGUS RIVER

PINES RIVER

REVERE BEACH

Point of Pines

LYNN HARBOR

NAHANT BEACH

NAHANT BAY

LITTLE NAHANT

BIG NAHANT

Bass Point

Cherry Island Bar Breakwater

Roughans Point

BROAD SOUND

N

LEGEND

12 FT. DEPTH CURVE

YEAR	AGENCY
1962	Corps of Engrs.
1945-46	" " "
1945	U.S.C.&G.S.
1895	U.S.C.&G.S.
1892	U.S.C.&G.S.
1853-54	U.S.C.&G.S.
1846-47-48	U.S.C.&G.S.

PROFILES

1945-46	U.S.E.D.

SCALE IN FEET

1000 0 1000 2000

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY A.D.C. | TR. BY A.D.C. | CK. BY T.C.B.

SUBMITTED: Oscar E. Goodwin, PROJECT ENGINEER

Oscar E. Goodwin, CHIEF COASTAL DEVELOPMENT SECTION

APPROVED RECOMMENDED: [illegible], CHIEF, PLANNING BRANCH

APPROVED: [illegible], CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

SHORELINE AND OFFSHORE CHANGES REVERE BEACH - 12 - FT. DEPTH CURVE

TO ACCOMPANY REPORT DATED: 28 MARCH 1968

SCALE

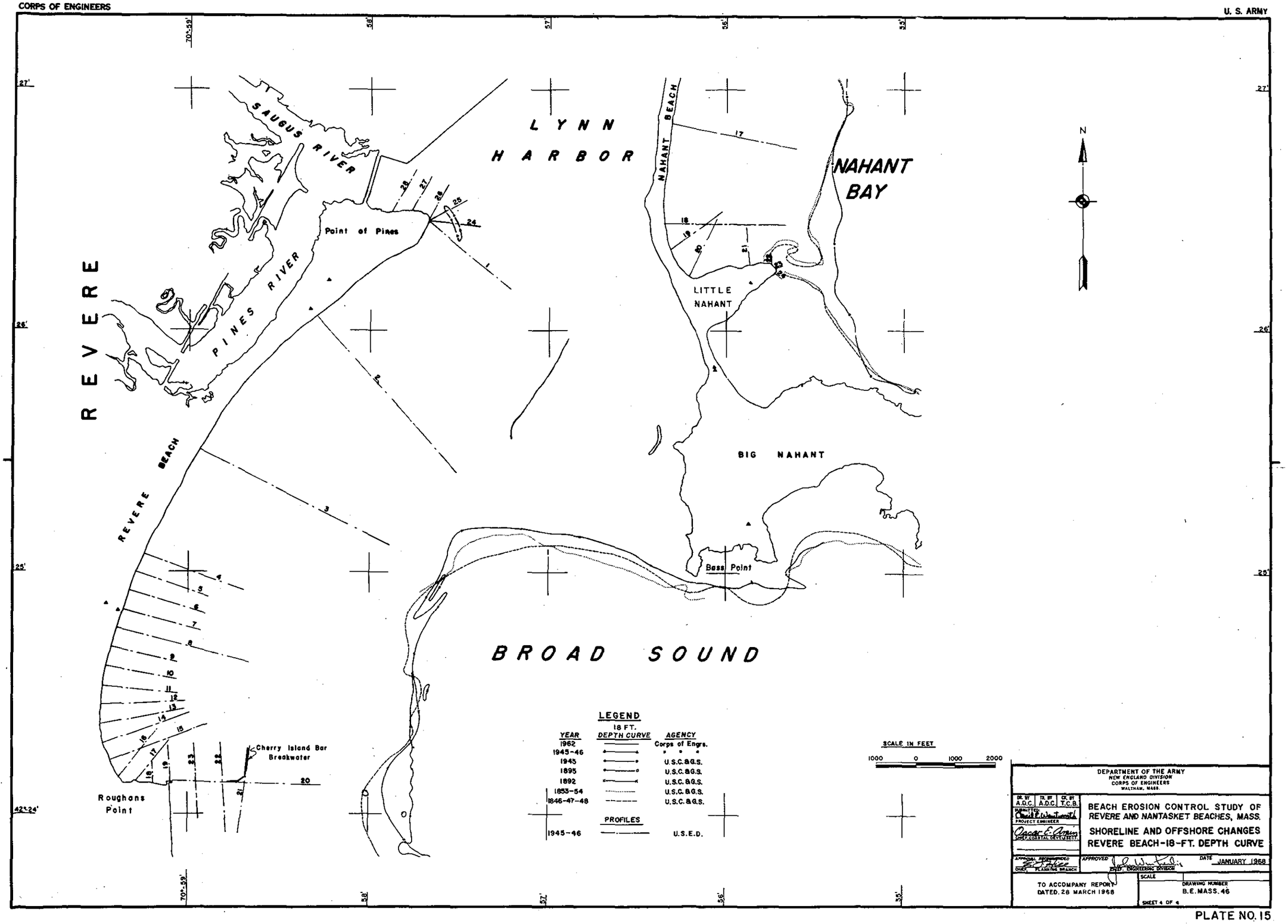
DRAWING NUMBER B.E. MASS. 46

SHEET 3 OF 4

PLATE NO.

CORPS OF ENGINEERS

U. S. ARMY



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: PROJECT ENGINEER

CHIEF, COASTAL DEVELOPMENT

APPROVED: CHIEF, PLANNING BRANCH

APPROVED: CHIEF, ENGINEERING DIVISION

DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

SHORELINE AND OFFSHORE CHANGES REVERE BEACH-18-FT. DEPTH CURVE

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

DRAWING NUMBER B.E. MASS. 46

SHEET 4 OF 4

PLATE NO. 15

CORPS OF ENGINEERS

U. S. ARMY

ALLERTON

Great Hill

NANTASKET BEACH

High Water Line

Low Water Line

HIGH AND LOW WATER LINES

Sagamore Head

WEIR RIVER

Atlantic Hill

6 – FOOT DEPTH CURVE

12 – FOOT DEPTH CURVE

18 – FOOT DEPTH CURVE

N

LEGEND

DATE	SHORE LINES & DEPTH CURVES	AGENCY
1963		Corps of Engrs.
1946		" " "
1944		U.S.C.& G.S.
1893		U.S.C.& G.S.
1847		U.S.C.& G.S.
	PROFILES	
1946		U.S.E.D.

SCALE IN FEET

1000 0 1000 2000

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

SHORELINE AND OFFSHORE CHANGES NANTASKET BEACH

APPROVED DATE JANUARY 1968

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

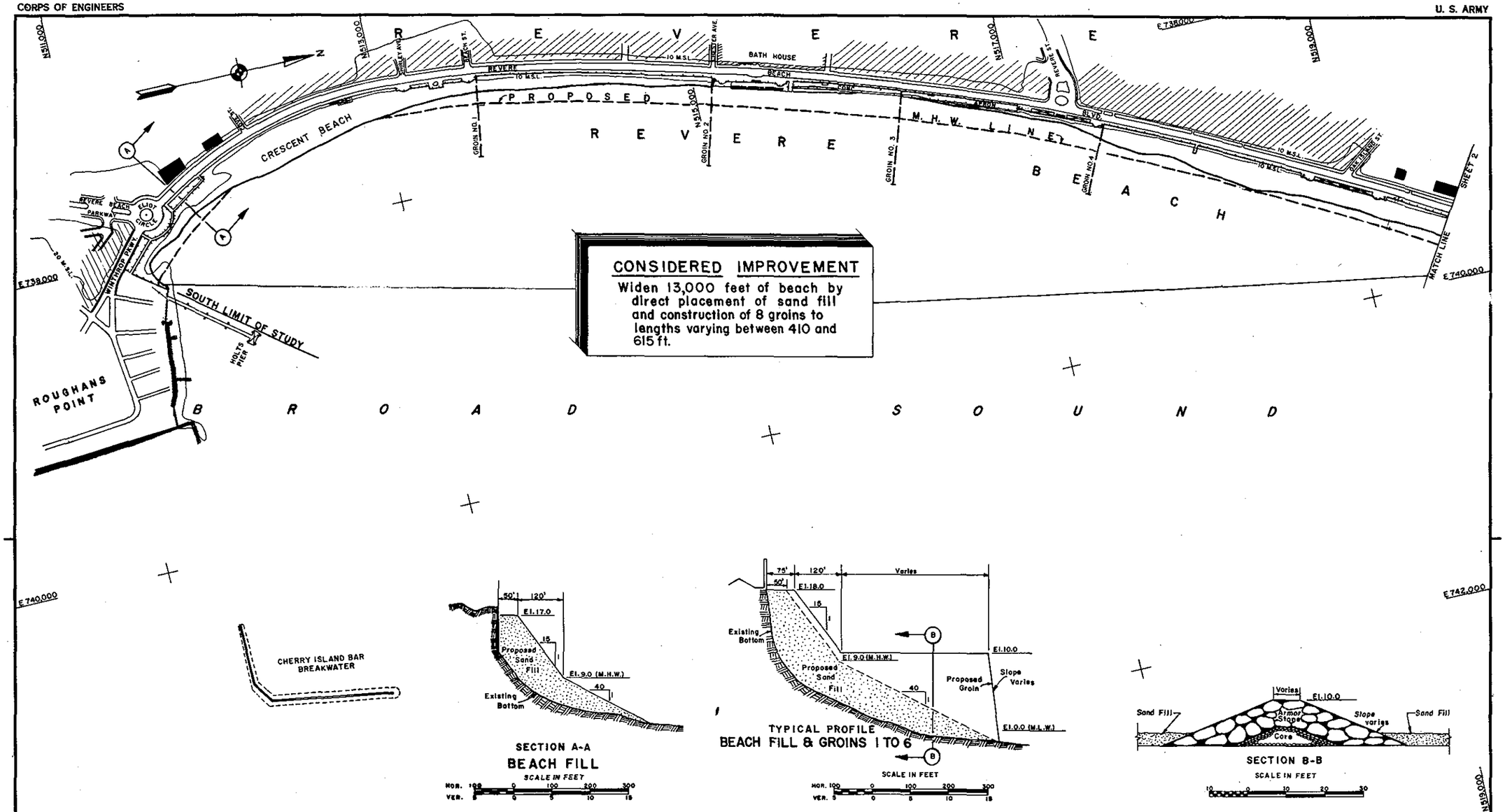
DRAWING NUMBER B.E. MASS. 47

SHEET 1 OF 1

PLATE NO. 16

CORPS OF ENGINEERS

U. S. ARMY



CONSIDERED IMPROVEMENT

Widen 13,000 feet of beach by direct placement of sand fill and construction of 8 groins to lengths varying between 410 and 615 ft.

SECTION A-A

BEACH FILL

SCALE IN FEET

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

TYPICAL PROFILE

BEACH FILL & GROINS 1 TO 6

SCALE IN FEET

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

SECTION B-B

SCALE IN FEET

10 0 10 20 30

LEGEND FOR SHORELINE STRUCTURES

Concrete

Wood

Stone & riprap

SCALE IN FEET

200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: Cecil E. Wentworth, PROJECT ENGINEER

Oscar L. Lopes, CHIEF, COASTAL ENGRG. SECT.

APPROVED: Chief, Engineering Division

DATE: JANUARY 1968

CHIEF, PLANNING BRANCH

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.
CONSIDERED PLAN OF PROTECTION
REVERE BEACH

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

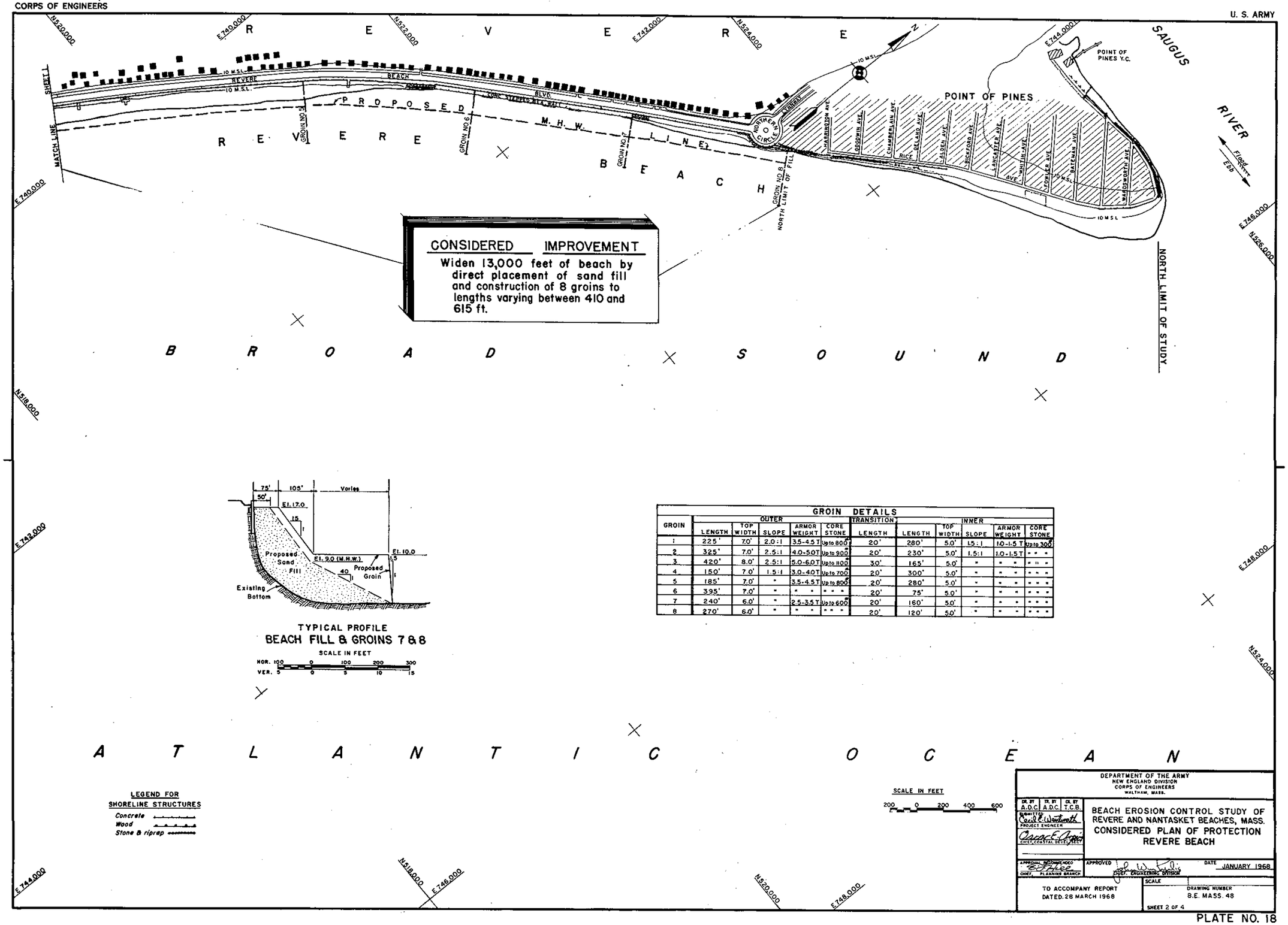
DRAWING NUMBER B.E. MASS. 48

SHEET 1 OF 4

PLATE NO. 17

CORPS OF ENGINEERS

U. S. ARMY



TYPICAL PROFILE
BEACH FILL & GROINS 7 & 8

SCALE IN FEET

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

GROIN DETAILS

GROIN	OUTER					TRANSITION	INNER				
	LENGTH	TOP WIDTH	SLOPE	ARMOR WEIGHT	CORE STONE	LENGTH	LENGTH	TOP WIDTH	SLOPE	ARMOR WEIGHT	CORE STONE
1	225'	7.0'	2.0:1	3.5-4.5 T	Up to 800 lbs	20'	280'	5.0'	1.5:1	1.0-1.5 T	Up to 300 lbs
2	325'	7.0'	2.5:1	4.0-5.0T	Up to 900 lbs	20'	230'	5.0'	1.5:1	1.0-1.5 T	" " "
3	420'	8.0'	2.5:1	5.0-6.0T	Up to 1100 lbs	30'	165'	5.0'	"	"	" " "
4	150'	7.0'	1.5:1	3.0-4.0T	Up to 700 lbs	20'	300'	5.0'	"	"	" " "
5	185'	7.0'	"	3.5-4.5T	Up to 800 lbs	20'	280'	5.0'	"	"	" " "
6	395'	7.0'	"	" "	" " "	20'	75'	5.0'	"	"	" " "
7	240'	6.0'	"	2.5-3.5 T	Up to 600 lbs	20'	160'	5.0'	"	"	" " "
8	270'	6.0'	"	" "	" " "	20'	120'	5.0'	"	"	" " "

LEGEND FOR SHORELINE STRUCTURES

Concrete

Wood

Stone & riprap

SCALE IN FEET

200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY A.D.C. | TR. BY A.D.C. | CK. BY T.C.B.

SUBMITTED Cecil E. Wentworth PROJECT ENGINEER

CHIEF, COASTAL DEVELOPMENT SECT.

APPROVAL RECOMMENDED E. Pike CHIEF, PLANNING BRANCH

APPROVED CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. CONSIDERED PLAN OF PROTECTION REVERE BEACH

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

DRAWING NUMBER B.E. MASS. 48

SHEET 2 OF 4

PLATE NO. 18

CORPS OF ENGINEERS

U. S. ARMY

N519,000

E738,000

E740,000

E742,000

E749,000

N513,000

N515,000

N517,000

N521,000

REVERE

BEACH

PROPOSED

M.H.W. LINE

CRESCENT BEACH

REVERE BEACH PARKWAY

ELIOT CIRCLE

WINTHROP PKWY.

SOUTH LIMIT OF STUDY

HOUTS PIER

ROUGHANS POINT

BATH HOUSE

REVERE BEACH BLVD.

MATCH LINE

SHEET 4

10 M.S.L.

20 M.S.L.

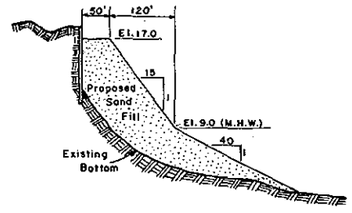
RECOMMENDED IMPROVEMENT

Widen 13,000 feet of beach by direct placement of sand fill, & periodic nourishment

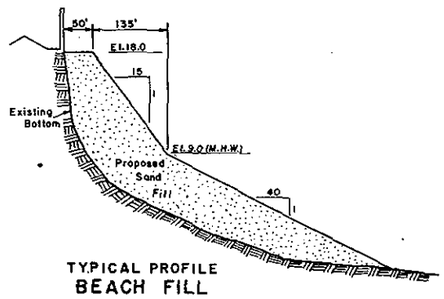
B R O A D S O U N D

A T L A N T I C O C E A N

CHERRY ISLAND BAR BREAKWATER



SECTION A-A
BEACH FILL
SCALE IN FEET
HOR. 100 0 100 200 300
VER. 5 0 5 10 15



TYPICAL PROFILE
BEACH FILL
SCALE IN FEET
HOR. 100 0 100 200 300
VER. 5 0 5 10 15

LEGEND FOR
SHORELINE STRUCTURES
Concrete
Wood
Stone & riprap

SCALE IN FEET
200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED
PROJECT ENGINEER

CHIEF, COASTAL DEVEL. BRCH.

APPROVAL RECOMMENDED
CHIEF, PLANNING BRANCH

APPROVED
CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.
RECOMMENDED PLAN OF PROTECTION
REVERE BEACH

TO ACCOMPANY REPORT
DATED 28 MARCH 1968

SCALE

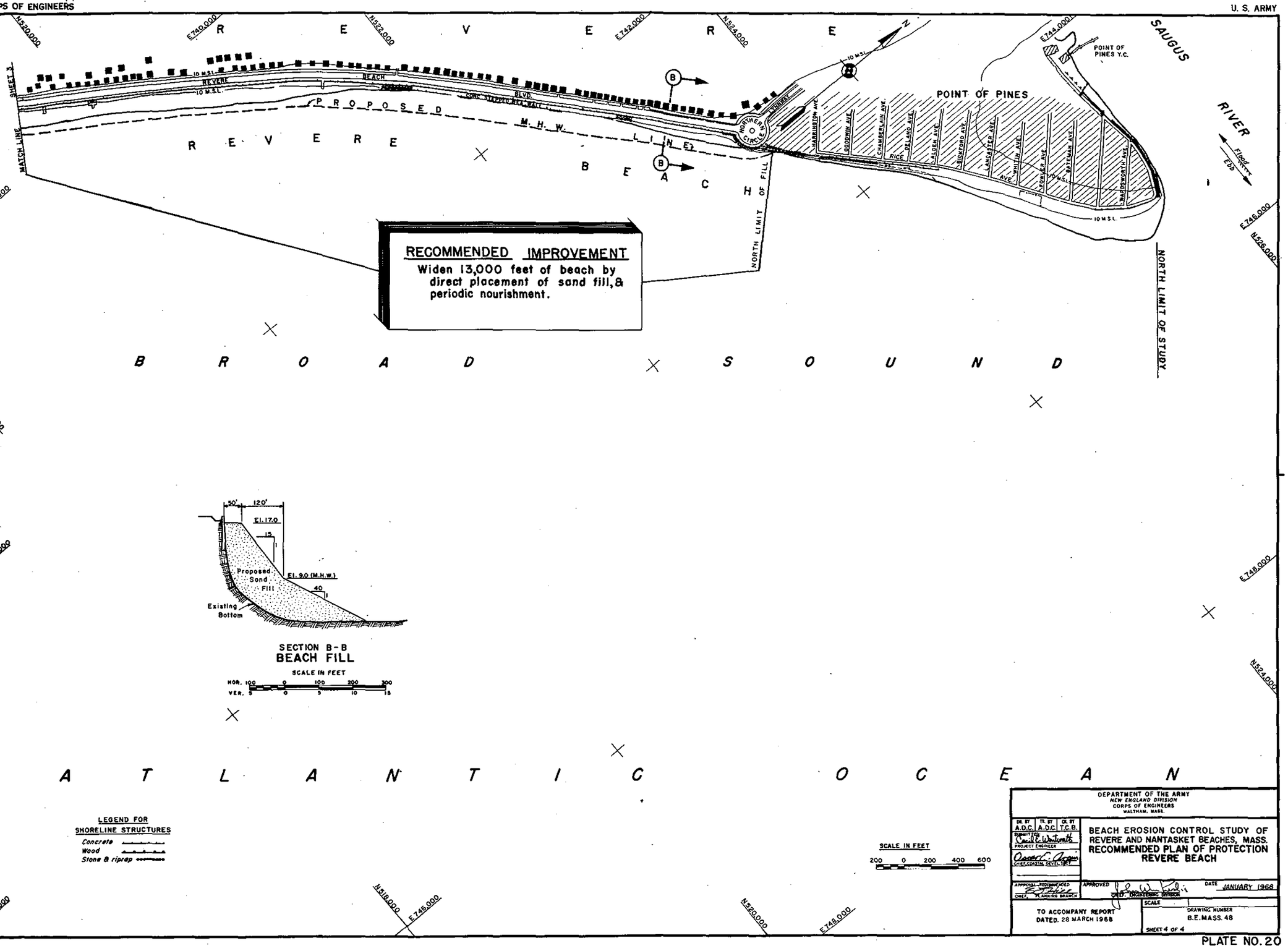
DRAWING NUMBER
B.E. MASS. 48

SHEET 3 OF 4

PLATE NO. 19

CORPS OF ENGINEERS

U. S. ARMY



SECTION B-B
BEACH FILL

SCALE IN FEET

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

LEGEND FOR SHORELINE STRUCTURES

Concrete

Wood

Stone & riprap

SCALE IN FEET

200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: Carl C. Wadsworth, PROJECT ENGINEER

Oscar C. Agerton, CHIEF, COASTAL DEVEL. SECT.

APPROVAL RECOMMENDED: Chief, PLANNING BRANCH

APPROVED: Chief, ENGINEERING DIVISION

DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. RECOMMENDED PLAN OF PROTECTION REVERE BEACH

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

DRAWING NUMBER B.E.MASS. 48

SHEET 4 OF 4

PLATE NO. 20

CORPS OF ENGINEERS

U. S. ARMY

E 773,000 | E 775,000 | N 459,000 | E 777,000 | N 456,000 | N 454,000

A T L A N T I C O C E A N

N

RECOMMENDED IMPROVEMENT

Widen 6,800 feet of beach by direct placement of sand fill & periodic nourishment.

E 771,000

N 462,000

SOUTH LIMIT OF STUDY AREA

ATLANTIC HILL

STATE PARK ROAD

BATH HOUSE

SOUTH LIMIT OF M.D.C. RESERVATION

NORTH LIMIT OF STUDY AREA

N A N T A S K E T B E A C H

PROPOSED M.H.W. LINE

SMALL ROCKS AND SAND

COMFORT STA.

MANOMET AVE.

NORTH LIMIT OF M.D.C. RESERVATION

PARKING AREA

HULL SHORE DRIVE

PARKING

M.D.C. BATH HO.

NANTASKET AVENUE

GEORGE WASHINGTON BOULEVARD

PARAGON PARK

OAK AVE.

H U L L

M.H.W.

N 468,000

N 456,000

E 771,000

N 454,000

E 771,000

189'

75'

El. 17.0

15

1

El. 9.4 (M.H.W.)

Proposed Sand Fill

Existing Bottom

40

1

El. 0.0 (M.L.W.)

TYPICAL SECTION

BEACH FILL

SCALE IN FEET

HOR. 100 0 100 200 300

VER. 5 0 5 10 15

LEGEND FOR SHORE STRUCTURES

Concrete wall

Stone or riprap

SCALE IN FEET

200 0 200 400 600

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
A.D.C.	A.D.C.	T.C.B.

SUBMITTED: Carl E. Wentworth, PROJECT ENGINEER

Oscar E. Agerter, CHIEF, COASTAL DEVELOPMENT SECT.

APPROVED RECOMMENDED: CHIEF, PLANNING BRANCH

APPROVED: CHIEF, ENGINEERING DIVISION

DATE: JANUARY 1968

BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS. PLAN OF PROTECTION NANTASKET BEACH

TO ACCOMPANY REPORT DATED 28 MARCH 1968

SCALE

DRAWING NUMBER B.E. MASS. 49

SHEET 1 OF 1

PLATE NO. 21